INDIAN TEA ASSOCIATION

TOCKLAI EXPERIMENTAL STATION

PROCEEDINGS

OF THE

FOURTH ANNUAL CONFERENCE

Held at Tocklai on the 15th, 16th, 17th February, 1940

1940

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PROCEEDINGS OF THE FOURTH ANNUAL CONFERENCE HELD AT TOCKLAI EXPERIMENTAL STATION

FIRST SESSION, 15th February, 1940, at 9-30 a.m.

Address by the Chairman

In opening this Fourth Annual Conference I should like to say how glad I am to welcome you as delegates. It will be your duty to judge the progress which has been made during the past year, in the work of the Department. You will probably be most interested in the field work, which you will have the opportunity of inspecting during this afternoon and to-morrow afternoon in company with Mr. Cooper.

It gives me particular pleasure to be able to welcome once again Mr. Lagden, the Chairman of the Indian Tea Association, Calcutta. We are very fortunate in having him with us for this Conference in view of the fact that he is so busy at the present time with the affairs of the tea industry. He has, I know, several matters of importance to discuss during this Conference.

The programme of the Conference will be much the same as in previous years. We shall meet here in the mornings at 9-30 a.m. to listen to various Officers speaking on subjects connected with their recent work, and to consider the questions sent in by the various districts. In the afternoons you will have the opportunity of visiting Borbhetta and of discussing any matters of particular interest to yourselves with the Officers concerned in their own laboratories. No formal arrangements have been made for the evenings. I am sure that all Officers will be pleased to welcome you in their own bungalows and to continue any discussions in which you are interested.

This year we have not received as many questions from the districts as in previous years, and this, I think, may be due to a certain amount of misunderstanding of remarks made at last year's Conference. It was not my intention to limit the number of questions but to confine them to matters of general interest affecting districts as a whole rather than individual gardens. Many questions received in previous years could easily have been answered by memoranda to the gardens concerned. What we wanted were questions of wider interest and it was for this reason that we suggested that questions should be put up to the District Associations for consideration before being forwarded to Tocklai. There was a suggestion put forward that this Department should be left to select those questions which it considered of general interest, but I consider

that you in your districts are better able than I am to judge of those matters which interest your district as a whole.

(The Chairman then gave the following report of the work of the Department for the past year.)

In giving you this report of the work of the Station I shall do no more than very briefly summarise the work since the individual officers will be giving during this Conference more detailed accounts of their work.

Pruning. -Experiments have been carried out to ascertain what may be the effect upon quality of different degrees of annual cleaning out. In 1938, cleaning out as is ordinarily practised at Tocklai, that is the removal of banjhi and weak shoots only, was compared with more severe cleaning out to the extent of spacing the shoots at a distance of 4" apart. No significant difference in quality was found. In a previous year bushes cleaned out on the Tocklai system were compared with bushes cut across but not cleaned out. The tea from the cleaned out bushes was preferred. This year extreme types of pruning have been compared—

(*i*) the removal of banjhis and weak shoots only (Tocklai) ;
(*ii*) stick pruning.

During the second flush period the average valuations are in favour of the bushes from which the banjhi shoots have been removed.

The stick-pruned teas throughout the experiment were never better than the tea from the lightly cleaned out bushes. The loss in crop was very great from the stick pruning; for instance up to the end of July the Tocklai pruning gave 4.64 mds. per acre whilst the stick-pruned crop was only 1.27 mds. per acre.

It is hoped that as a result of these experiments carried out for several years the excessive cleaning out of bushes will cease. From the experiments it seems that the removal of banjhi and weak shoots only, is necessary to ensure the best crop and at the same time the best quality for the early teas. No significant difference was proved between the teas made later in the season.

Plucking.—This was a replication of previous years' experiments to ascertain the difference in value of the teas resulting from variation of the fineness of plucking. On the first occasion of manufacture on the 18th May the leaf from all types of plucking, even three and a bud, was small and stunted. Good teas were made and well valued at Calcutta. There was very little difference in the valuation whatever the style of the plucking.

In this case it seems there was no advantage in maintaining a fine standard of plucking whilst this type of leaf was being plucked. So soon, however, as the leaves began to grow freely and shoots became larger, the teas made from less finely plucked leaf received a lower valuation. Thus in the manufacture on the 1st June, a fortnight later than the one above mentioned, the medium and coarse plucking gave teas valued at one anna and two annas respectively poorer than from the fine plucking.

Taking the values throughout the whole season there is no significant difference between superfine and the fine pluckings, all produced significantly better teas than the medium plucking which in turn gave significantly better teas than the coarse plucking. It is however of interest to note that the greater crop obtained by the freer plucking would have more than offset the loss in valuation, with the result that the freer pluckings would have given a greater monetary return per acre.

Plucking.		Mds. tea per acre 1939.	Average valuation 1939.
Coarse	...	12.7	9—8.5
Medium	...	10.2	10—8.6
Fine	...	7.8	11—7.9
Superfine	...	7.4	11—9.4

This experiment was carried out on a dark-leafed tea which gives relatively poor quality and never has much tip. On a better jat, differences due to plucking might well be more exaggerated, to the advantage of the finer plucking.

The superfine plucking consisted of shoots of one leaf and a bud and of 2 leaves and a bud only.

The fine plucking consisted of 2 leaves and a bud with a small percentage of the larger one and a bud and very few 3 leaves and a bud.

The medium plucking takes everything that is grown in a week down to the janam, and consists of about 30% 3 leaves and a bud. It includes no shoots of one and a bud.

The coarse plucking takes nothing finer than 3 leaves and a bud.

Manuring.—Comparison of teas made by using organic and inorganic manures has been again repeated and the results obtained confirm all previous experiments on this subject. No evidence whatsoever has been obtained to indicate loss of quality due to the use of inorganic manures in preference to organic manures. Valuations of the tea vary in accordance with the crop except that sulphate of ammonia gives a better tea

than might be expected from the crop. It is not proposed to repeat this experiment.

Fermentation.—The experiment dealing with thickness of spread during tea fermentation referred to in the Programme of Work for 1938 was not carried out, but it was possible to carry out another experiment to ascertain whether the thickness of spreading of small cut leaf, such as comes from the C.T.C. machine, would affect to any extent the rate of fermentation by restricting access of oxygen. The experiment showed no significant difference in rate of oxygen uptake between leaf spread at 1″ and 3″ thicknesses respectively.

A considerable amount of work has been done relating to the mechanism of the fermentation process in tea, as a result of which much insight has been gained into the nature of the chemical changes involved, and we are now in a position of understanding the main reactions of fermentation sufficiently well, we hope, to make practical application of this knowledge.

The results of this work, which are of a very technical nature, have been published in scientific form in a series of papers in the Biochemical Journal. It would, I think, serve no useful purpose for such papers to be published by the Indian Tea Association, nor would it be useful for me to enter into any detailed account of the work now. Dr. Roberts will be talking upon this subject during this Conference. I can, however, give you a brief summary of some of the more practical points.

The rate of fermentation varies for the same bush at different times, and varies within the jat from bush to bush, and also for different jats. Some jats, such as for instance Singlo, have been found to have a slow rate of fermentation as compared with China or Betjan.

In all our manufacturing experiments that have been carried out during the year the jat factor has proved to be the greatest. Wide variations in manufacturing conditions have resulted in little or no change in valuation but differences in jat have made a difference of 2*d*. per lb. of tea in average valuation, for Rains tea. Second flush teas were not examined.

During withering the cytochrome oxidase loses activity and consequently a slower rate of fermentation might be expected from well withered leaf, but. with the increase of withering, the permeability of the tissue is increased, and this seems to offset the loss in enzymic activity so that fermentation time remains very much the same with different degrees of wither. At very high withers a faster rate of fermentation is just noticeable.

Differences in plucking might also be expected to result in differences in the time of fermentation, since coarse plucked leaf contains less tannin than the fine plucked, but the fine plucking under the same withering conditions becomes more permeable, and again the time of fermentation remains much the same for the coarse and fine plucking.

A considerable amount of work extending now over several years has been done to ascertain the effect of temperature on fermentation. The results so far obtained can, I think, best be summarised that lower temperatures increase quality, briskness, and tint of colour, and the higher temperatures give increased strength and depth of colour of liquor.

One characteristic calls for particular mention:—the depth of the colour of the tea liquor is noticeably increased with the higher temperature but the tint of the colour also undergoes a change. This can be best appreciated if the tea has milk added to it. It will then be noticed that at the lower temperatures of fermentation, except in the case of very slow fermenting jats, there is an improved tint with the lower temperature, the tea having the rosy pink tint which seems to be so much appreciated.

How the different teas are valued depends largely upon the tasters for some will prefer the greater briskness, quality, and tint of colour obtained at the lower temperatures whilst others will value more particularly on the strength and depth of colour and will in general prefer a somewhat higher temperature.

It is, however, important to notice that whilst strength of liquor increases as the temperature rises from 60°F. to 80°F.; yet at 90°F. it is less than at 80°F.

An important point that has come out of this investigation is that the variation in temperature has a comparatively small effect upon the rate of oxygen consumption during fermentation. Some factor other than the oxidation of tannin must be accountable for the differences found between teas fermented at different temperatures. Tannin has the property possessed by a number of other chemical substances of condensing, that is to say of the molecules combining together, and it is the extent of condensation of the tannin molecule that is thought to be responsible for many of the tea characteristics. A study of the condensation of pure tea tannin is one of the outstanding problems of tea and I had hoped that it would be this problem that would be investigated in the scheme for tea investigation that is being carried on in England. Unfortunately this investigation seems to be taking another direction.

Humidity.—A study of the effect of humidity on fermenting tea could not be made as the cabinets for the control of temperature and humidity,

whilst satisfactory for temperature, have not given us all the conditions we required in regard to humidity. This work is on our programme for the coming year.

Flavour.—The work on flavour and aroma has been of a theoretical and preliminary nature, and as might be expected no practical results have yet been obtained.

Bacterial infection.—Further work has been carried out in connection with the bacterial infection of leaf while it is on the withering chung. Reference has been made to the infection brought about by borer excreta. It has now been shown that the insect responsible is not a borer but a species of termite which spends its life-history inside the split bamboo *kamies*. It has no direct connection with the earth. There is very little indication of its presence except the droppings and it is seen only when the *kamies* are broken. The infection of leaf by the droppings in relatively small amounts seems to result in giving a coarse character to the finished tea with loss of briskness and deterioration of colour in the infused leaf and liquor. A chemical investigation has shown that the extent of tannin oxidation is much greater than under normal conditions. Such leaf needs to be fermented for a shorter time: for instance, reducing the time of fermentation from 3 hours to 2 hours, resulted in a considerable improvement in the tea.

It is suggested that some form of ceiling cloth under the infested bamboo *kamies* should be installed to prevent the droppings falling on to the leaf spread on the lower withering chung. If possible it seems advisable to avoid the use of bamboos and to use wire instead. This can reduce the infection but the wire must be kept clean. If it is not kept clean it becomes coated with leaf juice and can impart infection to the leaf.

These investigations were also extended to include other forms of foreign matter which find their way on to the withered leaf. By passing withered leaf through a green leaf sifter prior to rolling, an extraordinary assortment of material consisting of broken and damaged buds which frequently become sour; hessian fibre, termite droppings, ants, and a variety of insects, insect wings, larvae, small particles of sand, brick and lime, etc., were obtained. As much as one lb. of such foreign matter has been extracted from the withered leaf going to a single roller. This material is characterised generally by an unpleasant smell. The use of a machine as described by Mr. Allan at the Third Annual Conference seems fully justified. Clean conditions in the withering space are required. It may not be possible to avoid insects, but sand, brick and lime originate in defective floors and iron rust from insufficient painting of the iron structure.

The teas made at Tocklai are noticeably better in colour and briskness than teas generally from the district and it has been difficult to ascribe this to any particular cause. The matter therefore was one for investigation. It has been found that after rolling, the bacterial infection of the leaf at Tocklai is usually much less than from estate factories, and that the method of rolling exercised considerable control. This has led to an investigation with different kinds of rolling, which is being continued.

Other points on general factory infection are worthy of careful attention :—

(*i*) The necessity for clean withering houses. These should be cleaned after each day's manufacture, removing all old leaf not only from the chungs but also from the alleyways and floors after a bulk has been collected.

(*ii*) Frequent attention to the less obvious parts of a roller is important, as for instance the roller doors. These need to be kept thoroughly clean which involves more than just washing. In some cases as much as ¼ lb. of material has been collected from a roller door that has not been properly cleaned for a week.

(*iii*) It is also important to draw attention to the fact that metal trolleys do not keep clean automatically but need to be frequently washed during the time of manufacture.

Moulds.—The investigation in regard to moulds in finished tea is being continued. It is of interest to note that "gaping" the tea for as long as 15 minutes at 180°F. leaves still a large mould infection in the tea. This work is being continued.

Work has been continued on the control of Red spider. Mr. Comrie will be dealing with this a little later on and it is unnecessary for me to enter into any details now.

Borers in shade trees have also been receiving our attention and some information has been collected during the year.

The investigation dealing with starch in the tea roots is in progress, as is also the experiment on the healing of wounds, also the investigation on the nursery disease. These experiments have not yet reached a stage for discussion.

The experiments on Black rot have continued to show the inefficiency of a cold weather treatment.

The experiments on Thread blight are of interest as indicating further lines for investigation. Mr. Tunstall will be speaking on these subjects a little later during the Conference.

Tea Plant.—Various forms of the tea plant have been recognised and arranged in a series which shows imperceptible gradations from a light-leafed Assam to a China type. Dr. Wight in Memorandum No. 7, has summarised his impressions, gained while touring, of the cultural characteristics of different types of tea.

It has already been pointed out that there is a considerable degree of self-sterility of the tea plant. Varying degrees of compatibility have been demonstrated. Artificial pollination has been shown to give a much better set of seed from that obtained under natural conditions. The inadequate transfer of pollination is supposed to be the explanation.

It has been possible to obtain an approximation for the number of clones which must be interplanted in order to produce an average crop of seed. Nine clones are considered necessary. Four clones of unknown potentiality are likely to give a crop half that usually obtained in a large mixed population.

Immature fruits fall from the trees from the time of fertilisation to the time of dehiscence of mature seeds. There are two period when the fruit fall reaches maximum—

(*i*) soon after fertilisation

(*ii*) in the middle of the season.

This loss is being further investigated.

No difference can be found in the size or morphological characters of plants raised from seed originating at different positions on the stem of the seed bush. The percentage set of seed is the same for flowers in any position on the axis.

No difference can be found in the size of plants raised from floaters or sinkers. The percentage germination of floaters is however lower than that of sinkers.

Experiments are in progress dealing with both the pruning and manuring of tea seed trees.

Further progress in the vegetative reproduction of plants has been made. Bushes vary greatly in the readiness with which cuttings taken

from them produce roots. Those bushes which root readily have been selected and are being further examined.

The technique of bud grafting has been greatly improved, for whereas the percentage success was about 12 to 25% it has now been raised to 79% and it is hoped to improve upon this result.

The effect of removing bud wrapping has been investigated. Shorter wrappings than 21 days seem undesirable with poor stocks but with vigorously growing stocks and the scion buds in the desirable stage, a shorter period of wrapping may prove desirable. The height of insertion of the buds upon nursery stock makes no difference to the success of the graft.

Experiments conducted during the year have shown that the nature of the stock considerably influences the percentage success of the grafts. With good stocks the storage of budwood overnight made no difference to the success of the grafts but with a poorer stock, storage of the budwood was detrimental. The time of day had no influence on the success of the graft. The grafts appeared to be equally successful whether the buds come from good or bad bushes. The experiment has so far failed to show any difference between the manufacturing characters of a bush and the ability of its buds to unite with a particular stock.

Our official taster Mr. Gilchrist has examined over 3,000 manufactures from individual bushes and his results show a close and significant relationship between quality and briskness. This relationship is also shown in the tea manufactured from the mixed population of individual plots.

The tip in the tea is due to the hairs on the tea leaf and it varies with jat differences. It has also been shown that a high relative humidity or the heavy application of nitrogenous manures to the soil are both correlated with a lessened amount of hair on the tea leaf.

Manuring.—Two experiments dealing with young tea have yielded interesting new information.

Young Tea.—On the tea planted in October, 1935, 60 lbs. nitrogen gave a much better effect than 20 lbs. nitrogen, for the first time, in 1939, the fourth year after planting. On these plots, the effect of potash continues to be great. The effect of phosphoric acid is practically negligible, though there is a slight good effect when the nitrogen dressing is high. It is interesting to note that the light-leafed jat makes much better use both of nitrogen and of potash than the dark-leafed jat. We cannot say that this applies to all light-leafed or to all dark-leafed jats: but it is

interesting to note that jat can make so much difference to the ability of a bush to make use of manure.

On the tea planted in October, 1936, very good effects from 60 lbs. nitrogen per acre appeared in 1939, only the third year after planting. Effects from only 20 lbs. might have been as good, but we think that this tea, having been more lightly pruned, was in condition to use more nitrogen in its third year than the severely pruned tea planted in 1935. This tea was planted in 1936 both with and without sau trees at $45' \times 45'$ triangular. It is interesting to observe that where no nitrogen was used, the sau trees in 1939 produced a not significant increase in crop: here we expect to see definite gains from the sau trees very soon. The plots with shade trees and nitrogen gave significantly less crop than the similar plots with nitrogen but without shade. How long this bad effect of shade trees on well manured soil will persist, remains to be seen.

Shade Experiments.—It has to be admitted that our belief in the beneficial effect of shade is founded on general experience, unconfirmed by experiment. An attempt is being made to remedy this and the following experiments have been laid down, and in some cases preliminary yields have been recorded.

(*i*) On commercial gardens—

Five experiments with and without shade combined with manurial trials.

Four experiments with three varieties of shade combined with manurial trials.

Two experiments dealing only with varieties of shade.

One experiment dealing with the distance apart of shade trees.

(*ii*) At Tocklai—

One experiment started in 1936 deals with varieties of tea with and without shade and with and without nitrogen.

A new experiment planted in 1939 compares seven varieties of shade trees, and no shade, with and without potash, and with and without phosphate.

Nitrogenous manures.—Among nitrogenous manures, sulphate of ammonia continues to do better than concentrated organic manures and much better than bulky organic manures, both at Tocklai and in a number of experiments on commercial estates. At Tocklai 21 plots which have

had 120 lbs. inorganic nitrogen annually for ten years, with no organic matter except their own prunings, averaged 19 mds. tea per acre in 1939, and soil and bushes appear to be in splendid condition.

Potash and phosphate.—The experiments to ascertain the values of potash and phosphate carried out on tea estates have been continued, and new experiments have been started.

The 24 experiments started in 1935, 1936 and 1937 show very similar results in 1939 to those obtained in 1938.

In most cases the increase produced by applications of nitrogen is significant. With few exceptions applications of potash and phosphate give increases in crop far below that required for significance. From the number of apparent gains from potash and phosphate it seems likely that the addition of these substances to the soil does help the bush to produce more leaf, but such applications will not generally pay commercially.

Twenty new experiments have been started to include more types of soil in the investigation.

On the big manuring plots at Tulsipara the same result has been registered, namely a significant increase from nitrogen, but only indications of increases from potash and phosphate.

At Tocklai we meet with an exception only in regard to potash on young tea, the increase from which is still highly significant in 1939.

Cultivation.—There is a new experiment at Tocklai comparing the effects of 2, 4, 6 and 8 light hoes, each with 3 different cold weather treatments, and with different dressings of sulphate of ammonia. The land was clean at the start of the experiment. In the first year, there was no effect at all from increased depth of cultivation, and relatively small effects from increased frequency of cultivation: the crops being 11.4 mds. from 2 light hoes and 12.4 mds. from 8 light hoes. On the older plots, we found similar small effects in early years. Results from greater frequency of cultivation are expected to increase as the under-cultivated plots become more thickly infested with weeds. The good effect from an extra 30 lbs. nitrogen per acre was the same whether cultivation was very little or very intensive, being 1.2 mds. tea per acre.

The older plots, both at Tocklai and at Tulsipara, gave results similar to those of previous years, indicating that suppression of weeds is the effective factor in cultivation.

It is regretted that it has not been found possible to extend these investigations to other types of soil, on commercial estates, but it is hoped that this will be remedied when the Advisory Officers take up residence in their respective districts.

Plucking.—The closer the plucking the greater the crop, though the appearance of the bushes indicates deterioration, and the gains from closer plucking decrease with time.

At Tocklai in the first year of treatment we lost 1.4 mds. tea per acre for every additional 2″ extra additional growth left: but in 1939 the fifth year, the difference is only 1 md.

At Tulsipara we gained over a maund of tea in 1932, the first year of good crop; but we gained only half a maund in 1939, from plucking at 6″ instead of 8″.

Other Experiments.—In addition to these experiments, the following subjects are under experimental investigation on commercial gardens:—

Composts.
Autumn and spring manuring.
The value of sulphur.
Potash to young tea.
Four levels of nitrogen on shaded tea.
Sulphur and lime.
The manuring of tea seed trees.
Hard and light plucking.
The two-stage top prune.
The light and heavy medium prune.
The pruning of young tea.
The biennial and triennial prune.

Experiments on Estates.—Last year I expressed the hope that the number of experiments carried out on tea estates might be increased and I am glad to say that we have had an excellent response in that we have been able to lay down 28 new experiments.

Owing to the outbreak of war towards the end of the year and to the general uncertainty it was decided that experiments that were not then in being had better be postponed. I am glad to say that in some cases it is now found possible to make arrangements for experiments to be initiated and it has been found possible to continue the experiments that were started before the outbreak of war. We hope it will be possible to carry on these experiments without any break in their continuity.

Home leave.—Mr. Harrison and Dr. Wight went on home leave during the year. Owing to the outbreak of war they both returned before the termination of their leave.

Lecture Courses.—Much general uncertainty and anxiety as to the future was unavoidable during the early stages of the war and the Indian Tea Association, rightly I think, decided that it was better to postpone for the year the holding of the Lecture Courses.

With the introduction of compulsory registration and the clarification of the situation in regard to national service there no longer exists the same uncertainty, and I have suggested to the Indian Tea Association Committee that Lecture Courses shall be resumed and held as customary at the end of this year.

Advisory Officers.—The District Advisory Officers have remained in residence at Tocklai throughout the year. They have toured in their respective districts.

Mr. Macgregor joined the Department as Senior Advisory Officer in August, 1939. His bungalow was supposed to have been ready for him before the end of the year, but unfortunately we were involved in a land sale case and had to postpone building until the Assam Land Revenue Tribunal had issued their judgment. This involved us in a delay of six months.

Tea Dictionary.—During the year there has been under preparation what we have termed "A Dictionary of Tea." It is suggested that this may be issued in the form of loose-leaf circulars which can be kept bound together, and additions and revisions easily added in their proper places. None of these have yet been published. I should like the delegates attending the Conference to examine the material that has been collected and to let us know their views in regard to this publication. Your respective Advisory Officers will be able to show this material to you.

Specimens.—The number of specimens sent in for examination continues to increase. This year we received 4,723 of which the Mycological Branch received 2,330 as against 1,430 last year.

During the year the Annual Report for 1938, 5 Memoranda; Nos. 6 to 10 inclusive, and 2 Circulars were issued. The latter were in the form of loose-leafs, and were in fulfilment of the suggestions made by Mr. Burton at the last Conference.

Telephone.—The telephone system has been installed in accordance with the suggestion made at the last Conference.

Mr. Burton raised the matter of the questions from districts and said that in his opinion questions sent in by Managers should not be put up to Sub-District Committees but should be considered by the delegates. Mr. McLennan pointed out that the Assam Branch Indian Tea Association, at the Meeting on 12th of this month, agreed that these questions should be put to a committee consisting of the three Assam delegates, for consideration before forwarding to Tocklai.

Mr. McLennan asked whether it was true that low temperature fermentation experiments had not proved successful in Ceylon.

The Chairman said that the experiment in Ceylon had been carried out at high elevation where the normal temperature was already low.

Mr. Tunstall mentioned that some years ago he had examined leaf on a high elevation Ceylon garden and had found it to be apparently free from both yeasts and bacteria. This fact might have something to do with the non-success of low temperature fermentation.

Mr. Scott asked whether conditions during the early second flush referred to on page 2 of the Report would be considered abnormal or whether it should be taken that coarse plucking can be adopted generally at that time of the year.

Mr. Cooper said that short periods of stunted growth were of almost annual occurrence in Assam, but that they were much rarer in the Dooars for example. Only when growth was clearly stunted could 3 leaves and a bud be taken with impunity.

Mr. Boyle asked whether it was agreed that freer plucking might generally be adopted in Upper Assam during early second flush when the leaf was stunted with Green Fly.

Mr. Cooper said that it was his advice to take everything ready in 7 days including shoots of 1 leaf and a bud, and that if this was done there was little fear of obtaining very coarse leaf.

Mr. Pearson asked whether banjhi leaf came under a similar category as the stunted leaf referred to by Mr. Cooper, who replied that there was a tendency to increased quality, but not of course tip, from *soft* banjhi leaf and that it would pay to encourage pluckers to pluck such leaf and not to leave it on the bush until it became hard. *Old* banjhi leaf definitely made very poor tea.

Mr. Scott asked whether the experiments on low temperature fermentation were carried out with C.T.C. leaf and if so could they be considered to apply to leaf tea.

The Chairman said that Dr. Roberts would discuss this matter later in the proceedings.

Mr. Lagden commended the proposal to issue an Encyclopaedia of Tea in looseleaf form and suggested that various authorities in the tea districts might be consulted with a view to obtaining additional terms and their definitions.

The Chairman then called on Mr. Macgregor to address the Meeting on the problem of Shade in Tea.

Mr. Macgregor then addressed the Meeting as follows:

This address answers the following question submitted to the Conference, from the Halem district of Assam.

Manuring of Shaded Tea.—It is felt that insufficient is known on this subject and that it is one of great importance especially at this time. It is desired to know whether Tocklai have any experiment to show the effects of soluble chemical fertilizers such as sulphate of ammonia on tea under shade as against similar tea unshaded. The effects of cessation of manuring well shaded mature tea which has been accorded normal manuring in past years and the whole question generally of manuring shaded areas. If definite research has not been carried on on these lines, it is considered of the utmost importance that experimentation should be undertaken immediately. Probably it would be easy to find garden managers who would be prepared to assist."

Many years ago we suspected that the Nitrogen supply to tea was the controlling factor where crop is concerned. It was realized that the nitrogen could be supplied in two ways, either directly in the form of fertilizers or indirectly by interplanting tea with leguminous trees.

A great deal of experimental work has been done with nitrogenous fertilizers. The results of these experiments have confirmed our belief in the value of this element and what little expenditure has been incurred is fully justified.

We have, as a result of these experiments, a very shrewd idea of the comparative value of the various forms in which nitrogen is commonly applied. We know, moreover, what the cumulative effect of a particular fertiliser is likely to be. This knowledge is of the utmost importance to the industry, and could only have been determined by careful experiment.

When we come to consider shading in detail, we find that our knowledge of the subject has reached only the same stage as our knowledge

of fertilizers reached 20 years ago. We are in fact forced to rely upon general experience. However, one very definite fact has emerged and that is, that although both shade and fertilizer, when applied separately do increase the crop, the result is most disappointing when they are applied together.

In statistical parlance this is known as the negative interaction between shade and manures.

At the present time this interaction is in most urgent need of examination.

It is interesting to see how this important effect has gradually come to be realized.

In our early experiments with Nitrogen we chose areas of tea which were as even as possible. In the majority of cases this meant little or no shade. There were, however, plots on which the shade was fairly heavy. Some of these experiments showed increases in crop of 50% or more from 90 lbs. of Nitrogen. Some, on the other hand showed 10% or less.

Our first explanation was that different soils reacted differently to the manurial dressings.

If this had been the case we should have expected that the gardens on which the experiments were carried out would respond to fertilizers to the same degree as that shown by their experimental plots, since, as far as possible, soils typical of the garden had been chosen for experiment.

It was generally disappointing to find that the gardens as a whole did not respond to manuring so well as the tea on the experimental plots; while, occasionally, where only small increases had been recorded on the plots, the gardens themselves reacted just as well to manuring as any others.

The theory, that uneven application of the manures when applied on a commercial scale might be responsible for the anomaly, was tested, but extremely careful supervision seemed not to help at all.

It has long been known that leguminous plants grown in poor soils fix nitrogen more efficiently than those grown in rich soil. Mr. Cooper formed the hypothesis that the capacity of a shade tree to fix nitrogen was considerably reduced by dressings of nitrogen, and in this light the discrepancies between experimental evidence and garden experience were examined.

The increase from manuring on many experiments, particularly on local gardens, was observed to conform roughly with the shading of the plots. This explained why as a general rule the effects from manuring on a commercial scale were comparatively disappointing; for, as already explained, unshaded areas had been generally chosen for experiment.

Had comprehensive experiments been put out we should have found this out many years ago, but experimentation on gardens was never popular. Shade experiments require large areas and owing to the unevenness of the shade trees on the average area and the consequent likelihood of inaccuracy, it is hardly surprising that more easily controlled experiments should have received preference.

It may be unsafe to take the results of experiments with bush legumes as indicative of what may be expected from leguminous trees, but an experiment with boga medeloa at Borbhetta may be quoted as an illustration of the interaction between the effect of a legume and the effect of nitrogen.

No benefit has yet resulted from growing boga medeloa in manured tea; a significant loss occurred in the first year whether the medeloa was lopped or unlopped.

Stated summarily—if you are prepared to manure there may be no profit from growing medeloa in the tea. I can not however let this pass without reminding you that the shade from Boga medeloa materially reduces cultivation costs, a point which must not be lost sight of.

Treatment		1936	1937	1938	1939	Total in 4 yrs.
Without sulphate of ammonia ...	No Boga medeloa ...	8.30	8.15	7.16	6.75	30.36
	Lopped Boga medeloa ...	7.63	7.92	7.90	7.88	31.33
	Unlopped Boga medeloa ...	7.41	6.66	9.06	10.15	33.62
With sulphate of ammonia ...	No Boga medeloa ...	10.35	11.39	12.28	11.35	45.37
	Lopped Boga medeloa ...	9.64	11.21	13.34	12.19	45.38
	Unlopped Boga medeloa ...	9.53	8.02	11.50	13.72	41.77
Significant difference ...		.56	.78	.79	.95	

But to return to the use of Leguminous trees.

Apart from what experience has taught us we have one experiment at Borbhetta, on an area planted in October, 1936, from which interesting results have already been obtained.

This experiment deals with 11 jats of tea with and without nitrogen and with and without shade.

	Without shade.	With shade	Effect of shade.
Without Nitrogen ...	3.96	4.07	0.11 Gain.
With Nitrogen ...	5.66	4.80	0.86 Loss.
Gain from Nitrogen ...	1.70	0.83	

The difference required for these losses or gains to be significant is 0.329 mds.

From this experiment we have already learned (1) that during the first few years of its growth shade may be expected to reduce the yield of manured tea, or conversely, that areas under young shade will not pay for manuring as well as areas unshaded.

(2). Even where no manures are given the value of young shade is problematical in its early years.

The harm may be due simply to the taking by the sau trees of nitrogen which the tea might have used. In that case the loss may prove to be temporary, but we cannot exclude the possibility that cases may occur where mature tea is better without shade trees on well-manured soil. The whole question certainly needs examination in such a manner that the effects of the various factors can be separated.

On the normal garden, therefore, we must regard shade as a long term investment.

Several experiments which I shall enumerate later, are in the process of being laid down and I want to discuss some of the problems related to this question which we are endeavouring to solve.

(1). The nature of the Nitrogen and Shade interaction.

On shaded areas we find that the increase in crop brought about by nitrogenous manuring is proportional to the quantity of nitrogen applied up to, say, 60 lbs. per acre, in other words by plotting nitrogen-applied against yield, we get a straight line curve.

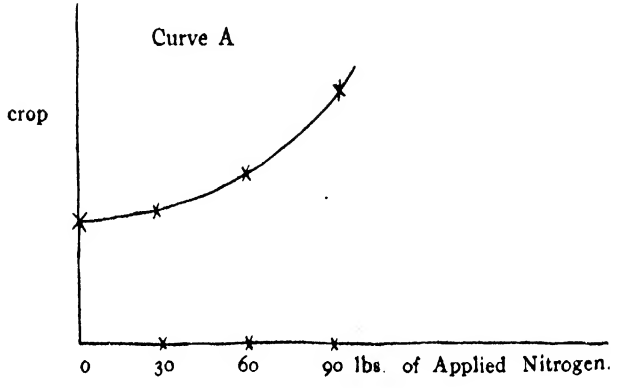
Is this so on shaded areas?

We can conceive, though it is unlikely, that 30 lbs. of nitrogen might prevent all nitrogen fixation by the shade tree, and if the value of the

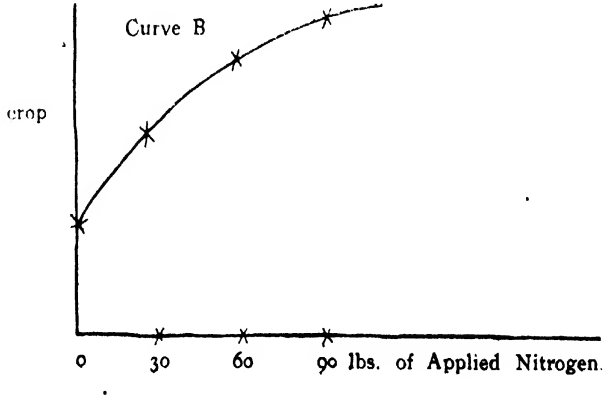
fixed nitrogen was equivalent to 30 lbs. of applied nitrogen, then by the application of 30 lbs as fertiliser, our crop will remain unchanged.

We shall then expect that 60 lbs. nitrogen on a shaded area would give the same increase as 30 lbs. on an unshaded area: or 90 lbs. under shade will equal 60 lbs. unshaded.

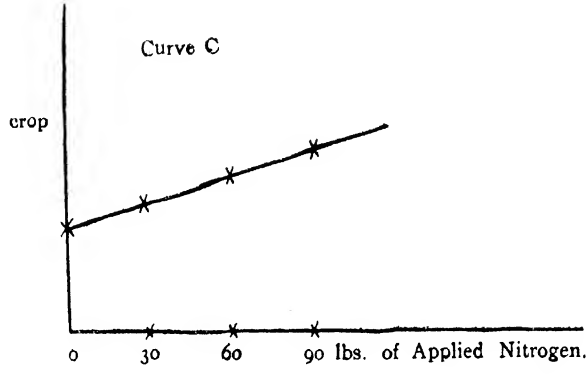
Our curve will take this form—



Conversely we may find that small dressings of 30 lbs. of nitrogen do not seriously affect the efficiency of the tree but that as the dose is increased its power to fix nitrogen falls off rapidly. Our curve will then be—



Or the straight line curve associated with manurial experiments on unshaded areas may still be found to hold, the slope of the line being less steep.



If curve A is correct it will be useless to apply small dressings of fertiliser. If curve B is correct small dressings will prove the most economical: and, if curve C, the straight line curve, is correct we shall have to decide whether or not it pays to manure at all. This will depend upon the slope of the line. Possibly some other programme of manuring will have to be tried, such as large dressings every three or four years But first we must learn the shape of the curve.

(2). Effect of Potash and Phosphate on Nitrogen fixation by shade trees.

We know that on many tea soils dressings of phosphate in particular do have a very beneficial effect on leguminous crops such as Boga medeloa and Cowpea. It is only reasonable to assume that they are beneficial also to leguminous trees, and it may be found that shade trees in general are more efficient when supplied liberally with phosphate, and perhaps with potash also.

It might be found that where dressings of phosphate are given the slope of curve C is steeper. That is to say that we shall get more benefit from our nitrogenous fertilizers.

(3). Species of Shade tree.

Experiments with Jats of Shade tree are obviously of great importance, it is hardly likely that all the leguminous trees are equally efficient, yet in almost every district we find this kind of cycle going on.

Sau is planted because it appears to do most good to the tea. The sau begins to get canker and to die and is uprooted. Koroi is planted because

it gets less canker. This is uprooted because the trees are so big and the cost of uprooting those which die is prohibitive. Bormedeloa, a healthy slow growing tree, is put in its place; but since in the opinion of the Manager it seems to do the tea beneath it so little good, it in turn is uprooted and once again the area is planted with sau.

Only when the various trees are planted side by side, can we get a true comparison, and only in a carefully laid out experiment can we determine the real benefit to be expected from any one jat of tree.

(4). Distance apart of shade.

Equally important is it to find out the optimum amount of shade desirable. This will vary from one species to another and from one district to another.

But we have gone far enough to go on with. How far is that?

If we carry out a trial of 6 different species of shade tree manured with three levels of nitrogenous manure this gives us $6 \times 3 = 18$ trials. Again if each of these 18 trials is carried out at 3 levels of phosphate manuring, the number of trials now becomes $18 \times 3 = 54$. At 3 levels of potash manuring the number of trials now becomes $54 \times 3 = 162$; and finally if these are combined with three different spacings there will be 486 trials without any replication!

In such an experiment repeated 4 times we must be prepared to find that the different jats benefit the tea most at different levels of nitrogen, at different levels of Potash, at different levels of Phosphate, at different spacings; in fact the fourth order interaction may be significant and we shall get 486 answers to our problem from rather less than 2,000 plots.

2,000 plots is not yet a practicable proposition but I mention it to show the magnitude of the problem so that you will not be too impatient for the results.

At the same time I do not wish to frighten potential experimentalists from contributing to the vast amount of information which we urgently require, and there is no necessity for the various subjects referred to above to be combined in one cumbersome experiment. Thus an experiment on one garden might well be designed to contribute some information on the Nitrogen × Shade interaction, another on the Potash × Shade interaction while a third could be laid out to deal with the problem of spacing.

I hope it will be realised that most of what I have had to say refers to effects and interactions about which we know extremely little. What

we do know is that dressings of nitrogen are far less effective in raising the crop on shaded than on unshaded areas. Whether established shade is of any value on well manured areas is doubtful; young shade on such areas definitely depresses the yield.

It is sincerely hoped that offers will be forthcoming to run experiments on many gardens situated widely apart, and in this connection a comprehensive Memorandum will be forwarded on enquiry.

Up-to-date, arrangements have been made for fourteen experiments to be started on commercial gardens. These have already been referred to by Mr. Carpenter.

We are extremely indebted to Messrs. Duncan Bros. & Co. Ltd., Messrs. James Finlay & Co. Ltd., and Messrs. Williamson Magor & Co. Ltd. and their Managers for carrying out experiments on the following Gardens:—

Messrs. James Finlay & Co. Ltd.—

Kakajan.
Noyapara.
Hingajea.

Messrs. Duncan Bros. & Co. Ltd.—

Allynugger.
Borokai.
Doloo.
Rampore.
Meenglass.
Ellenbarie.
Jiti.

Messrs. Williamson Magor & Co.—

Behora.
Rajmai.

Mr. Scott asked what was the size of plots proposed by Mr. Macgregor for shade tree experiment.

Mr. Macgregor said that a plot of 200 bushes containing two shade trees was the optimum size of plot for ordinary shade experiments, but that these dimensions would naturally have to be greatly increased for experiments where distance apart of shade trees was the subject.

The Chairman referred to a new method being employed at Borbhetta for shade tree experiments in which the plots were hexagonal in shape with one shade tree in the centre.

Mr. Lagden referred to other possible effects of shade trees apart from manurial effect on crop; for instance their effect on the atmospheric temperature, and Mr. Macgregor replied that he had not by any means mentioned all of the possible influences which shade trees might exert on the tea and agreed that climatic factors were of great importance.

Mr. Burton referred to the great value of shade trees as fuel, and said that on many gardens short of natural fuel supplies, the regular removal of dead and old shade trees provides a big annual supply of fuel for the labour force.

Mr. Cooper said that he was glad that this point had been brought up because some gardens refused to plant shade on account of the cost of its removal.

There was a discussion on the actual cost of removal of shade trees and Mr. Burton summed up the situation by saying that the problem depended to a very great extent on the natural supply of fuel available on any particular garden.

The Chairman referred to the practice on a garden in Java of systematic removal of shade trees which were primarily grown for fuel. The trees were felled leaving stumps in the ground and the tea had not apparently suffered from Root Rot. The shade trees were *Albizzia moluccana*, a quick-growing and quick-rotting species. Some gardens in North-East India, especially with certain types of shade tree, would almost certainly run the risk of trouble from Root Rot if stumps of the shade trees were not removed.

Mr. Pearson asked whether as a general rule all the common types of shade tree grew equally well.

Mr. Macgregor replied that as far as his experience of shade trees in this district was concerned, all the common shade trees grew equally well and that any difficulty in establishing any particular variety was more often due to faulty planting.

Mr. Pearson said that in his district growth varied considerably between different types of shade trees even on different parts of the same section.

Mr. Scott asked whether it would not be possible for the Advisory Officers to collect observational information in their own districts on the best type of shade tree to grow.

Mr. Cooper replied that it would be better to obtain such information by experiments.

The Chairman thought that Mr. Scott's suggestion would result in useful information.

Mr. Boyle asked whether there were any experiments on the problem of Canker in sau trees.

Mr. Tunstall said that generally sau trees were more liable to attack when they were reaching old age. He suggested that the natural life of a sau tree in tea was not more than about 25 years and there were many fungi capable of causing canker when a sau tree was approaching this age. If young sau trees were interplanted among old cankered trees then the canker was transmitted to the young plants, but if all the shade were uprooted and the area completely replanted with young shade, these were not so liable to canker.

Mr. McLennan remarked that he had seen instances of young sau trees, in replanted areas quite separate from old trees, being attacked by canker.

The Chairman suggested that some varieties of sau tree might be more susceptible to canker than others.

Mr. Cullen questioned the advisability of planting shade at all on replanted tea, except of course on southern and western exposures which obviously required protection from the sun. There surely could be no question of shade trees taking the place of artificial manuring on replanted tea. He pointed out that Borbhetta was a good example of excellent tea established without any shade at all—and on indifferent land.

The Chairman said that the shade experiments at Borbhetta showed that if anything the better manured and faster growing shade trees seemed to be more liable to canker than the slower growing unmanured trees. This observation should be taken with caution until confirmed by more exact experiments.

Mr. Cooper referred to the question of manuring shaded areas and pointed out that an experiment at Borbhetta showed that a shade tree exerted a good influence on the surrounding tea only for 4 or 5 rows of bushes. If possible one would like to confine the manuring of shaded areas to those portions which were outside the influence of shade trees, where the manure could exert its maximum effect on the tea.

Mr. Scott suggested that in cases like this it rather indicated that the shade was planted too far apart but Mr. Benton pointed out that if the planting of shade were too close there was the risk of a bad effect on quality.

Mr. Cooper gave it as his tentative opinion that ordinary sau trees should be planted not more than 40 ft. apart, if shade alone is to be relied upon: but at present they are not generally so close and there are spaces between them which would benefit from manure.

Mr. Comrie then gave the following account of Borers in Shade Trees.

In March, 1939, I paid a visit to the North Bank to examine damage to shade trees. The cases where it was possible to be certain that the damage was the direct action of insects were in the case of Bormedeloa, *A. Stipulata*, and Koroi.

The damage to Bormedeloa was caused by a boring larva which occurs most commonly in the bottom six feet of the trunk and throws out masses of droppings. The damage appeared to be mainly in the wood of the tree and it was not possible during my visit to obtain a tree to split it up and find the larva in order to identify it. Some control was obtained by injecting a chloroform-creosote mixture into the holes. Any other volatile poison such as carbon bi-sulphide would be effective. It would assist greatly if specimens of the larvae could be obtained, but this means the sacrifice of one or two trees.

In the case of *A. Stipulata* the damage was the result of the action of the larvae of a small beetle of *Mecistocerus sp.* These larvae bore into the bark and throw out small worm-cast-like masses of excreta. Their activities appear to be confined to the surface of the bark and beyond being unsightly did not appear to do any really serious damage. These larvae were being effectively dealt with by small hammers—one blow on the bark at each cast being sufficient to crush the larva. How the bark of the trees has reacted to such treatment during the ensuing year I have not yet heard.

The Koroi pest is the metallic Buprestid Beetle, *Sternocera sternocornis*. This beetle is the one used as a decoration by the coolies and is on the wing in August and September. The eggs are very large for insect eggs and are either dropped onto, or laid in, the soil. These hatch in December to January to give the characteristic hairy larva. These feed on the roots of the Koroi nursery plants and lead to an extensive loss of plants. The control is not very easy but damage to nurseries could be reduced if the soil were kept clean of weeds and a search made for eggs between September and January. Catching of adult beetles too would reduce the number of eggs laid. From reports received it would appear that the adults do extensive damage to the leaves of Koroi by feeding on them. At this time in the life history a fair degree of control could be gained by catching the beetles which are large and easily seen.

The more extensive bark damage on the shade trees was not easy to diagnose—the damage on certain areas gives the impression of the presence of a double set of factors. For some reason a patch of bark dies and fungi or bacteria gain entrance, in these damaged tissues several forms of insect larvae find suitable living conditions. In one case they gave the impression that they might be helping to extend the damage by attacking healthy wood at the edge of the damaged area but in most cases the margin of decay and edge of the insect borings were so close that it is not possible to say which is really the cause of the spread of the area, *i.e.*, whether it is that the insects advance and the fungi follow or whether the insects follow the fungi. By examining a series of shade trees during the season it appears that there is a tendency for the death of the bark to occur due to the entrance of some organism. The reaction of the tree is to produce wound gum which oozes out and gives the appearance that insects are attacking the tissues. This wound reaction is some distance in advance of the dead area. Whether this death is due to fungal or bacterial agencies I am unable to say. The point of entry of attack is not always evident and may at times be through a crack in the bark, though in many cases it appears to occur where a branch has fallen off and so left a wound to allow entry of the attacking organism. The majority of such patches had Long horn beetle larvae present and as these are common in dead wood, they must be regarded as secondary inhabitants.

A. moluccana trees which were beginning to show signs of old age and to die off were attacked by the beetle *Nystocera festiva*. This damage was only apparent in parts of the trunk from which the bark had fallen or been removed—and it would thus appear that it was really dead wood that was being attacked.

The Chairman pointed out that more information from the districts was needed on diseases of shade trees and much help could be given to the Department by sending in specimens of insects, etc., found attacking the trees.

Mr. Tocher referred to the question of lopping of shade trees and said that the time of the year and the care exercised in lopping must have a considerable influence on freedom from canker and other fungus diseases.

Mr. Cooper asked why lopping was generally considered necessary.

Messrs. Tocher and Scott agreed that it was certainly necessary when the tree was young in order to produce a high canopy.

Mr. Evenden said that in Darjeeling in his opinion lopping was considered advisable as low grown shade appeared to encourage Blister blight.

Mr. Pearson said that Mosquito blight was considered to be less if trees were well lopped up.

Mr. A. C. Tunstall then addressed the meeting on the subject of Black Rot and Thread Blight.

Black rot is caused by two species of *Corticium*. The commoner is *Corticium invisum* and the other, *Corticium theae*, is somewhat rare in North-East India. These fungi belong to the same order as the common mushroom. *Exobasidium vexans*, the cause of Blister blight, *Septobasidium spp.*, the cause of the Velvet blights all belong to this order—the *Basidiomycetes*. The *Corticium spp.*, associated with Black rot have not been found to penetrate the tissues of the host plant. Another species found in tea, *Corticium dealbans*, does penetrate the bark cells but so far has not been found in the living tissues. *Corticium salmonicolor*, occasionally associated with branch cankers, penetrates living tissues to a limited extent. In the case of *Corticium salmonicolor* a semi-resistant form has been observed in the tissues. Another species produces nodules which are highly resistant to fungicidal treatment. It is therefore not unlikely that the species which cause Black rot on tea do, on occasion, form bodies resistant to fungicidal treatment. Nobody has actually observed such bodies so far but there is some evidence in favour of their presence.

During the past few years it has been possible to carry out scientifically designed experiments on the control of Black rot in the field. By our system of observation the progress of the disease in hundreds of individual bushes has been recorded for a series of years. These observations have shown very clearly that the disease remains on the same bushes year after year and that the number of newly infected bushes is comparatively small. Although the disease is not noticeable during the cold weather months it seems to be present on the bushes throughout the year. If this be true the style of pruning may influence the number of infected bushes.

Pruning.—Pruning off all apparently diseased material and removing it from the area failed to effect any improvement. This is not surprising as at the usual time of pruning most of the signs of infection have disappeared. Hence only a comparatively small percentage of the infected material is removed. Stripping off all the leaves also failed to effect any improvement. In medium pruning most of the leaf bearing portion of the frame and those portions most likely to carry infection are removed. This is usually followed by an almost complete removal of the Black rot. We have no definite experiments showing this but I think that it is common experience.

Our experiments have shown that in years when the plots were unpruned the number of diseased bushes tended to increase while in the

years when the bushes were light pruned there was no significant increase. We have no figures to illustrate the effect of cleaning out on Black rot.

Our experiments and other observations show that carrying off prunings has no appreciable effect on the incidence of the disease.

So far we have had no significant result from applications of spray fluids in the dormant season. At the moment I do not propose to try more spray fluids in the cold weather. It may be possible to effect a reasonable reduction of the disease by severe cleaning out, but the loss in crop resulting from this operation may be greater than that caused by the disease. In cases of severe infection it may, of course, pay to make a sacrifice in one season in order to enable control to be established and maintained in subsequent years. And we require to carry out further experiments to ascertain what, if any, degree of cleaning out is necessary to effect a significant reduction in the disease.

Treatment during growing season.—All our experiments, 14 in 1939, have shown that the systematic spraying of diseased bushes whenever the disease appears to be active has significantly reduced the numbers of infected bushes.

On a garden in Upper Assam the observations on experimental plots were continued for four successive years. The information obtained from these observations gives a good idea of the value of the treatment concerned.

The following figures were obtained from a garden in Upper Assam. They afford a useful record of the progress of establishing control of the disease. Only the diseased bushes were treated. Treatment was repeated whenever necessary.

The percentage of bushes, which were found to be infected in the course of the year concerned, are tabulated below:—

Treatment	1935 before treatment	1936	1937	1938	1939
A. 4% Burgundy mixture with rosin adhesive ...	72	68	41	32	18
B. 4% Burgundy mixture without rosin adhesive ...	81	64	41	36	26
C. 1% Burgundy mixture with rosin adhesive ...	78	70	44	44	22
D. Lime sulphur solution 1 in 5 30° Beaume concentrate ...	85	77	58	56	34
E. No treatment ...	78	72	68	67	47
Sign. diff. (P=·05) all figures	...	...	...	...	11

The observations were made at each round of plucking throughout the season. In the early part of the season the disease does not show up. It is, however, obvious during about 20-25 rounds of plucking. If every bush in a series is seen to be infected throughout the season the total figures for the degree of infection would be the total number of bushes in the series multiplied by the total number of rounds of plucking. The following figures are percentages of this total and may be called the degree of infection.

Treatment	1936	1937	1938	1939	1939 % of 1938
A 4% Burgundy mixture with rosin adhesive ...	10·2	11·2	11·6	2·2	19·0
B. 4% Burgundy mixture without rosin adhesive ...	10·7	10·1	10·3	2·9	28·1
C. 1% Burgundy mixture with rosin adhesive ...	13·9	12·1	12·5	2·4	19·1
D. Lime sulphur solution 1 in 5 30° Beaume concentrate ...	46·5	15·2	20·0	5·5	27·5
E. No treatment ...	75·0	66·9	55·1	31·8	57·7
Sign. diff. (P = ·05) ...	...	...	...	5·8	...

Another interesting piece of information is the average duration of the obvious infection on the bushes expressed in weeks.

Treatment	1936	1937	1938	1939
A. 4% Burgundy mixture with rosin adhesive ...	2·65	2·61	3·44	2·77
B. 4% Burgundy mixture without rosin adhesive ...	2·89	2·50	2·66	2·49
C. 1% Burgundy mixture with rosin adhesive ...	3·77	2·89	3·38	2·64
D. Lime sulphur solution 1 in 5 30° Beaume concentrate ...	12·56	3·65	5·45	3·52
E. No treatment ...	20·26	16·05	14·88	14·90
Sign. diff. (P = ·05) ...	...	...	...	1·29

The yield for the four years expressed as a percentage of the yield of the untreated series is given below:—

Treatment	1936	1937	1938	1939	Total
A. 4% Burgundy mixture with rosin adhesive ...	108·0	108·7	109·9	110·6	109·3
B. 4% Burgundy mixture without rosin adhesive ...	108·8	111·7	107·2	111·0	110·0
C. 1% Burgundy mixture with rosin adhesive ...	107·3	110·4	111·1	109·0	109·6
D. Lime sulphur solution 1 in 5 30° Beaume concentrate ...	103·5	111·1	107·6	109·9	108·4
E. No treatment ...	100·0	100·0	100·0	100·0	100·0
Sign. diff. (P. = ·05) ...	...	...	...	...	2·7

The 1939 figures show a significant negative correlation between the degree of infection and the yield.

It would appear from the above figures that a difference of 3% degree of infection and 2.7% of infected bushes give about 1% reduction in yield.

On this garden the average yield of the check series of 500 bushes was 850 lbs. of green leaf. This is equivalent to about 12 maunds of dry tea per acre. So 10% is 1.2 maunds of dry tea.

The amounts of spray fluid applied in the last year were as follows:—

A. 48 gallons to 252 bushes = 1·90 gallons per 10 bushes.
B. 50 „ „ 320 „ = 1·56 „ „ „ „
C. 51½ „ „ 288 „ = 1·75 „ „ „ „
D. 71 „ „ 598 „ = 1·19 „ „ „ „
E.

The above figures show that in practice 1% Burgundy mixture is as good as 4% if applied to diseased bushes as soon as the disease is noticed. The gradual improvement associated with Lime sulphur solution is worthy of note. The solution used was of course much more concentrated than that usually applied for red spider.

Thread blight resembles Black rot in many ways. It is, however, quite distinct from Black rot. The fungus does not penetrate the living tissues and it would seem probable that the thorough application of a fungicide would kill it out at any time of the year. Since we inangurated observations of individual bushes on a large scale it has been found that Thread blight, like Black rot, does not respond to cold weather spraying. We have tried various fungicides, including two Winter Washes. The results are disappointing, not a single instance of a significant reduction in the number of bushes found to be infected in the following season has been recorded.

On a garden in the Dooars an experiment was commenced in January 1938 and continued to-date. The figures so far obtained are as follows:—

	1938 before treatment	1939	1940
Ordinary pruning only	157	193	220
Cleaned out	151	171	170
Cleaned out and treated with lime wash	129	148	151
Cleaned out and treated with lime sulphur	138	151	152
Cleaned out and treated with 1% Burgundy mixture and kerosene emulsion	131	115	158

It will be seen that the big drop occurs between the Pruned only and the Cleaned out. All three fungicidal treatments seem to have caused some reduction but it is not significant.

If we take the number of bushes found infected in January 1938 which recovered in the course of the following two years and adjust the figures by Fisher's co-variance method on the 1938 totals we get the following, expressed as percentages of the pruned plot.

Ordinary pruning	100.0%
Cleaned out	165.0%
Cleaned out and treated with lime wash	152.0%
Cleaned out and treated with lime sulphur	157.5%
Cleaned out and treated with Burgundy mixture and kerosene emulsion	177.5%
Sign. diff. (P=.05)	50.0%

Again the cleaning out is associated with a significant rise in the percentage of recoveries but the fungicidal treatments do not differ from series which has been cleaned out only.

The number of new infections also failed to yield any significant differences but there is a suggestion that the cleaning out reduced the number of new infections also.

Another experiment was carried out on the same garden. Two proprietory Winter Washes and Lime sulphur solution were applied to three series of cleaned out plots. Again the cleaning out showed up against the ordinary pruning but the results were not significant. They may become so in the 2nd year of treatment.

As these two experiments did not show any significant differences in one year it would be wise to defer judgment on the others until the 2nd years' figures are available.

So far the only hopeful result has been from cleaning out. It may be pointed out that on sections left unpruned in alternate years the Thread blight is likely to increase if no treatment is applied.

I consider that it would pay to spray any bushes showing obvious signs of damage from Thread blight in the rainy season. Bushes on which the blight has to be searched for may be ignored. Fluids containing copper are superior to sulphur mixtures for this purpose.

Mr. Burton said that clean pruning appeared to be the most helpful solution of the problem as far as cold weather treatment was concerned, and Mr. Tunstall agreed. Mr. Mackay asked whether districts where clean pruning was general, were freer from Black rot than those where clean pruning was not the rule. Mr. Tunstall said that in general this was so but that there were exceptions. For instance even when clean pruned, tea in certain situations suffered badly. Areas enclosed by jungle might be very susceptible and improvement had frequently been effected by cutting back the jungle edges.

Mr. Macgregor asked whether flaming of the bushes in the cold weather with torches, had been tried.

Mr. Tunstall said that this had been done years ago in Darjeeling for Thread blight with apparently good results and was a treatment worth investigating.

Mr. Pearson asked if Whiz had been tried and Mr. Tunstall said that they had tried two kinds of Whiz and many other kinds of spray fluid but none had proved of any use as a cold weather spray. He said that

Peronox (Cuprous oxide) might prove to be a valuable rains spray fluid. Experiments were being carried out with this material. Replying to another question from Mr. Pearson Mr. Tunstall said that there was no completely satisfactory sprayer, but Vermorels had proved as satisfactory as any.

Mr. Scott asked whether it was necessary to bury prunings from areas affected by Thread blight.

Mr. Tunstall said that there was no need to do this as experiments showed no difference in the subsequent extent of the disease whether prunings were buried, left to lie on the ground, or carried off.

Mr. Pearson referred to a particular instance of a piece of high plateau tea of about 12 acres which was 100 per cent infected with Black rot. This area was surrounded by jungle. After the jungle had been cut back there was very much less Black rot in the following year: moreover, Mosquito blight was reduced, and by the third year all signs of Black rot had practically disappeared.

Mr. Benton asked whether it was a question of atmospheric humidity or whether it was the effect of allowing free flow of air across the tea, and whether they had noticed that Black rot increased in a year when the weather was duller than usual.

Mr. Pearson said that in 1930, a year of heavy rain and long spell of dull weather, Black rot was actually less than usual in his district.

The Chairman then called upon Dr. Roberts to address the Meeting on the subject of Fermentation.

Dr. Roberts.—For the last two years I have been busy working out the biochemistry of tea fermentation and I now think sufficient progress has been made to justify communicating my conclusions to this Conference. In any piece of scientific research a glimpse of the truth may lead to conclusions being drawn, which in the light of further experience, may have to be drastically revised. For this reason I have been reluctant until now to say much about this work, and have contented myself with recording the results in scientific periodicals.

I do not claim to have solved the problem completely. Much work remains to be done, but I feel that the broad outlines have been established, and what conclusions I am drawing stand comparatively little risk of being shown to be faulty.

We must not consider Tea Fermentation to be an isolated phenomenon. The darkening of many plant tissues after damage, such as for

example the browning of a peeled apple, is completely analogous to the development of the bright copper-red colour in mechanically rolled tea-leaf. The damage to the tissues has interfered with the very delicate balance of the respiratory process, and consequently to understand tea fermentation we must know something about the normal process of respiration in plant tissue. This is rather a specialist's subject, and I do not propose to deal with this at the moment.

It has been shown that the rate of fermentation is controlled by the amount of an enzyme present in the green leaf, which has been identified with a reasonable degree of certainty as cytochrome oxidase. This enzyme indirectly assists the oxidation of the tea tannin during fermentation. Enzymes such as this cytochrome oxidase are present in such small amounts that they can be assayed only by a measurement of the effects they exert. A technique has been developed, in which the cytochrome oxidase activity may be estimated in terms of so many Q_{O_2} units. These units are quite arbitrary and represent the rate at which oxygen is consumed in the preliminary stages of fermentation. For an average good fermenting jat, the Q_{O_2} value is about 20. For such a Q_{O_2} value an all in fermentation time of 3 hours is required at 85°F. An approximate relationship exists between the Q_{O_2} value and the time of fermentation at 85°F, such that—

$$Q_{O_2} \times \text{fermentation time in hours} = 60.$$

Seasonal Variation.—The Q_{O_2} value of leaf of one jat, from a particular plot, varies somewhat irregularly from week to week. For a jat such as Betjan or Tingamira, the outside limits for Q_{O_2} are from 17 to 23 which correspond to fermentation times of $3\frac{1}{2}$ and $2\frac{1}{2}$ hours respectively. Serious variations in the optimal time of fermentation, for different times of the year, are therefore not anticipated.

Jat Variation.—Generally speaking there is little difference in fermentation rates with jat. Betjan may ferment faster than China one week, and slower the next, but over the whole season there is no significant difference between the two. The Singlo, and its daughter Kharikatia, that we have in the Tocklai clearance, are however slow fermenters, and their Q_{O_2} values are always significantly lower than those for good fermenting jats such as Betjan. We find a distinct improvement in teas from these jats by extending the time of fermentation by $\frac{3}{4}$ to 1 hour above that required by normal jats. Despite this improvement, however, the tasters never value such teas so highly as those from better fermenting jats.

Single bushes.—We have carried out a few preliminary experiments on leaf from single bushes. Generally speaking, bushes which yield teas

of good strength (utilising the Botanist's results for single bush manufactures), have a high Q02 value and it is anticipated that this method of characterisation of bushes will be of use in selection work. Already bushes with as high a Q02 as 32 have been found, and we should anticipate that bushes of this type would be very desirable ones for propagation on a strength basis.

Effect of temperature.—We now come to the somewhat debatable point of the effect of temperature on quality. Before we go into this subject it is necessary to consider the chemistry of the process a little.

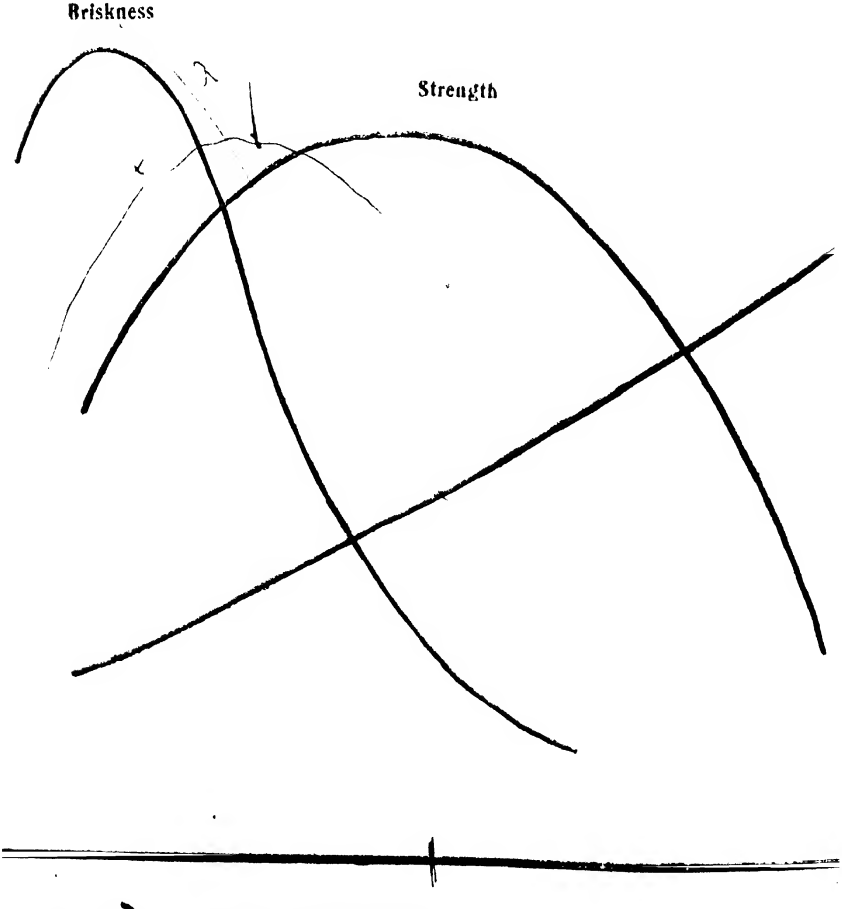
It has been established that the tannins in tea undergo two distinct types of chemical change during fermentation. The more obvious of these is the oxidation by atmospheric oxygen, and it has been shown that under normal conditions of manufacture about 90% of the tannin in green leaf is oxidised during fermentation. After oxidation, the oxidised tannins have the power of combining with each other to form more complex molecules. This process is known as condensation, and the ability of oxidised tannins to condense is apparently unlimited. The initial condensation products seem to be able to condense with each other or with freshly oxidised tannin molecules, and consequently, when the process is stopped by firing, a whole range of condensation products exists in the made tea.

The oxidation of tea tannin is a process involving enzymes and consequently is not affected by temperature in quite the same way as a normal chemical reaction. Generally a chemical reaction doubles its speed for every 18°F. rise in temperature, but, with an enzyme reaction, high temperatures act in the opposite direction as enzymes are destroyed by quite moderate heat.

It has been shown experimentally that there is very little variation in the rate of oxygen consumption by fermenting tea leaf over a considerable range of temperatures (70—100°F.). The two opposing effects of a higher temperature, *viz.*, greater rate of chemical reaction, and greater extent of enzyme inactivation, seem to cancel each other out.

Condensation of oxidised tannins is not an enzymic process and is subject to the general laws of normal chemical reactions. Consequently temperature of fermentation has a marked effect on the nature of the fermentation products. For the same degree of oxidation the tannins will be much more highly condensed at high temperatures of fermentation than at low temperatures. This chemical difference between low and high temperature fermented teas is reflected in differences in their liquor characters.

We have reason to think that briskness is a character associated with a low degree of condensation. Further condensation is presumed to be accompanied by a fall in briskness, but by an increase in strength, which seems to be a property of moderately highly condensed tannins. Once this degree of condensation is exceeded, however, strength falls off, and teas can be obtained in which the tannins are so highly condensed that the liquor has neither strength nor briskness. The *depth* of colour increases continuously with increasing condensation. These relations may be depicted in the form of curves.



It will be noticed that emphasis is laid on depth of colour. As you all know, teas which are almost black in colour, may be manufactured. Up to a certain point depth of colour is desirable, but a good tone of

colour is also required. Tasters who use milk, generally express the opinion that the most desirable colour is that which gives a rosy colour on the addition of milk. This tone of colour seems to be best developed under conditions which result in a high degree of briskness. These conditions produce a low degree of condensation, and hence a comparatively low intensity of colour. Tasters who do not use milk, therefore, often prefer the colour of a liquor considered inferior on the milk test.

These theories on condensation and liquor characters may seem to you to be based on nothing more than mere assertion, so I should like to back them up by showing how the observed variations in liquor characters with time and temperature of fermentation, fall in line with those predicted by this theory.

During 1939 two experiments were carried out by the Chemical Department on the effect of time and temperature of fermentation. As usual, these teas were subjected to a panel of tasters who valued them and assigned marks for the various characters. In the tables below are given the average marks for teas fermented under varying conditions. The figures in the table are means of five or six tasters (except where otherwise stated) and for six or eight manufactures.

I. Betjan Tea. Means of six manufactures.

Character	Tasters	60° F			80° F		
		2½	3½	4	2½	3½	4 hours
Infused leaf ...	A-E	4·9	5·3	5·2	4·9	5·4	5·3
Colour (with milk)	A	3·8	4·7	4·3	3·5	3·5	3·3
Colour ...	B-E	2·5	2·7	2·8	3·0	3·2	3·5
Strength ...	A-D*	2·2	2·4	2·5	2·4	2·7	3·0
Quality ...	A-E	2·8	2·8	2·8	2·6	2·5	2·3
Quality ...	A	3·5	3·3	3·3	2·5	2·3	1·2
Briskness ...	A-E	3·9	3·7	3·6	3·6	3·3	3·1
Briskness ...	A	4·0	3·8	3·3	3·3	2·7	2·2

II. Kharikatia Tea. Means of six manufactures.

Character	Tasters	60° F			80° F		
		2½	3½	4	2½	3¼	4 hrs.
Infused leaf ...	A-E	3·6	3·9	4·4	3·9	4·5	4·8
Colour (with milk)	A	0·8	2·2	2·8	2·2	2·8	2·5
Colour ...	B-E	2·0	2·0	2·3	2·4	2·9	2·9
Strength ...	A-D*	1·2	1·7	1·9	2·4	2·5	2·5
Quality ...	A-E	2·5	2·5	2·7	2·5	2·3	2·3
Quality ...	A	2·5	2·7	3·0	2·5	2·3	1·5
Briskness ...	A-E	3·9	3·8	3·6	3·6	3·4	3·0
Briskness ...	A	4·8	4·7	4·5	3·8	3·0	2·2

* Taster E submitted a minority report, in that he failed to find any variation in strength of liquor with time and temperature of fermentation, for either jat. His marks are therefore omitted in calculating the general average.

III. Light leaf jats. Betjan and Tingamira.

Means of eight manufactures and six tasters.

Characters	80° F		90° F	
	2½	3½	2½	3½ hrs.
Infused leaf ...	5·3	5·5	5·1	5·3
Colour	3·1	3·4	3·0	3·4
Strength ...	3·0	3·2	2·9	3·0
Quality ...	2·9	2·7	2·6	2·5
Briskness ...	3·9	3·5	3·6	3·2

IV. Dark leaf jats. Burma and Doolia

Means of eight manufactures and six tasters.

Characters	80° F		90° F	
	2⅔	3½	2½	3½ hrs.
Infused leaf ...	4·3	4·5	4·3	4·5
Colour	2·8	3·1	2·7	3·1
Strength ...	2·6	2·7	2·4	2·7
Quality ...	2·2	2·1	2·1	1·9
Briskness ...	3·6	3·1	3·3	2·9

An examination of these results together with those reported by Mr. Benton at the last Conference shows how well the "condensation" theory fits the facts.

For all jats briskness is maximal at 60°F. and 2½ hrs. fermentation. An increase in time or temperature produces a significant decrease in briskness. Under all cases investigated, increasing degree of condensation is associated with a decrease in briskness.

Quality seems to follow briskness although this does not mean that these two characters are identical. In my opinion, conditions which lead to a brisk tea are those that are the best for the development of flavour but this is a rather tentative conclusion.

Strength generally increases significantly with time of fermentation up to 3½ or 4 hours. There is also significantly better strength at 80°F. than at 60°F., but if the temperature of fermentation is increased to 90°F., strength is significantly lower. Benton showed that maximum strength decreased with temperature from 70°F. to 100°F. so we may conclude that strength is developed to its greatest extent at a temperature of about 70°F.

The time required to achieve maximum strength varies with the temperature. At 100°F. it decreases from any fermentation time beyond 2½ hours. Maximum strength is shown at about 3¼ hours at 90°F., 3¾ hours at 80°F. and just above 4 hours at 70°F.

Both Benton's results and my own therefore agree, in showing that the conditions for the development of maximum strength are very different from those for the maximum development of briskness.

Further, many tasters consider that a tea fermented to give the best possible strength is lacking a little in cup colour. This is emphatically not the opinion of those who taste with milk, but nevertheless, the objection of some tasters to the cup colour of teas which stand out for briskness or strength must be recorded.

It is obvious from these considerations, that a tea cannot be made which can combine the best possible briskness, strength and intensity of cup colour. One can only be developed at the expense of the others, but any one character may be pushed up to its maximum by a careful regulation of time and temperature of fermentation.

Oxy-fermentation.—I should like to conclude this talk with a few remarks on a new process in fermentation that has provoked some discussion—Warren's oxy-fermentation.

The cytochrome oxidase in tea leaf causes a much more rapid oxidation of tannins when the process takes place in an atmosphere of oxygen. The rate of fermentation is accelerated about threefold, and well-rolled leaf is ready for firing after 20 to 30 minutes fermentation in an oxygen atmosphere. This oxy-fermentation also disturbs the normal ratio of oxidation and condensation. There is not the time for condensation to proceed to the same extent as is usual, and consequently the manufactured product is much brisker and of better quality than that fermented under normal conditions. There seems to be a slight loss in strength, and cup colour is much lighter. Here, once again, the tasters are in agreement as to the effect of the process on the characters but disagree very much as to the market value of those changes. Some say the oxygen-treated tea is 9 pies better and some 2 pies worse, and every intermediate opinion is also recorded. For the time being therefore this new process must be considered *sub judice* but further experiments are in progress.

It should be emphasised that the times and temperatures of fermentation quoted throughout this paper refer to the special conditions reigning in the Tocklai Factory. Jat and variations in the hardness of rolling, to mention only two factors, may affect these figures considerably and for practical applications of these results each particular factory would have to be considered separately.

Mr. Lagden referred to the difference in opinion expressed by tea tasters as to the value they placed on the various characteristics of the tea liquors and asked whether the tasters had been requested to value for a particular market. He pointed out that a certain market would place a higher value on quality than another market which might prefer teas of greater strength though they had less quality.

Mr. Cooper said that tasters had been asked to value the teas as if they were to be sold that week on the Calcutta market.

Mr. Scott asked whether in the experiments on Fermentation, C.T.C. leaf was used.

Dr. Roberts said that it was, and explained the method of manufacture.

Mr. Scott suggested that as this method differed from that in practice on many commercial gardens the results obtained might be of little practical value to such gardens. It was pointed out that in Mr. Benton's earlier experiments on Fermentation no C.T.C. was used but exactly similar results were obtained.

Dr. Wight also mentioned that the results he had obtained from hand manufacture agreed with those obtained from C.T.C. manufacture.

Dr. Roberts added that he had obtained precisely similar results using minced leaf.

The Chairman exphasised that it mattered little how the damage to the leaf was brought about. Whether the manufacture was by such different processes as rolling or mincing the rate of oxygen uptake remained the same. He would have no hesitation in applying Dr. Roberts' findings to commercial manufacture on that account.

Mr. Lagden then addressed the Meeting and expressed pleasure on behalf of himself and the delegates at being able to be present at this Conference. He assured the Chairman that the Calcutta Committee were keenly interested in all that was being done at Tocklai, and would always try to maintain closest touch. He suggested that the Annual Report which they had just listened to was of such great interest to all concerned with the tea industry that it might be published as soon as possible. He pointed out that the Proceedings of the Conference might take some time before it appeared in print.

He thought that there was great scope for the Advisory Officers when they were stationed in their districts, to arouse even greater enthusiasm among the planters in carrying out field experiments similar to those already being carried out, and which had provided such valuable information.

SECOND SESSION, 16th February, 1940.

The Chairman in opening the second day's Meeting called upon Mr. Harrison to talk on the Effect of Plucking, Pruning and Manuring, etc., on the Quality of Tea.

Mr. Harrison.—Up to 1932 no definite evidence was available on the effect which factors such as manuring, plucking and pruning had on the character and value of the made tea.

This does not mean, however, that ideas, often very decided, were not held by various people both in the producing and in the marketing spheres of the industry, on the effects on quality of cultural factors such as have been mentioned. Some of these ideas have proved correct, but others have been shown to be very far from the truth. For instance, while the view that coarse plucking had a detrimental effect on quality has been borne out by experiment, it has been shown very clearly that the idea that excessively clean pruning resulted in better tea, is without foundation.

Commencing in 1932, a careful study of the effect of cultural factors on tea value has been made, and results have been reported annually, in Annual Reports of the Scientific Department; in one bulletin * (1936), (in which a detailed account of the technique of the experiments was given); and at the First Conference in 1937. I must mention here that the credit for the design and technique of these experiments belongs to Mr. Cooper.

The object of this address is to assemble the results of this eight-year programme of work, in as brief a form as possible, omitting all detailed tables of results.

The cultural factors whose effects on quality have been investigated, are—

Manuring. This has involved a study of the effect of nitrogenous manures (organic and inorganic) in different quantities; the effect of potash and phosphatic manures; the effect of time of application of nitrogenous manure; and the effect of application of manures such as lime and sulphur which produce large variations in soil acidity.

Put briefly all our results from many experiments indicate clearly that there is a slight decrease in value of tea from nitrogenous manuring, with any kind of nitrogenous manure, providing it is efficient enough to cause an increase in crop. The drop in value is proportional to the crop

* Experiments on the Quality of Tea.

increase, not to the quantity or kind of nitrogenous manure. When normal quantities of manure are used, (as for example, 200 lbs. sulphate of ammonia, 12 mds. of oilcake or 5 tons of cattle manure), though at Borbhetta they maintain a crop of about 4 mds. of tea per acre above unmanured tea, they do not result in any lowering of tea value which tasters can detect.

Any nitrogenous manure, organic or inorganic, however, if applied in sufficient quantity to double this crop increase, produces a detectable drop in the value of the made tea. Sufficient evidence has been accumulated to leave little doubt that the above statements are close to the truth.

I was always under the impression that among the older generation of planters, there existed an almost universal prejudice against the use of chemical fertilisers and in this connection it is interesting to read the remarks on the subject of manuring and quality made by Col. Money some 70 years ago.

> "**Manure.**—An idea existed formerly, got, I believe, from stray Chinamen, who I don't think knew much about Tea in any way, that manure, though it increased the yield, spoilt the flavour of Tea. The idea is opposed to all agricultural knowledge, for high cultivation, which in no case can be carried out to perfection without manure, much improves the strength and flavour of all edibles, the product of mother-earth. . . . ."
>
> " . . . After experience showed me that manuring nearly doubles the yield of plants and that so far from injuring the flavour of Tea it improves it, while it adds greatly to the strength. . . ."
>
> " . . . When it is considered how much is taken from the Tea plant, it is evident the soil will be exhausted, sooner or later, if no means are adopted to repair the waste. Where manure cannot be got the waste must be made up, as far as possible, by returning all other growth to the soil. But manure *should* be got if possible, for it will double the yield of a garden; and highly concentrated chemical manures will, I am sure, be eventually much used on Tea gardens. . . ."

Though we would hardly like to go as far as Col. Money did in claiming that manuring improves flavour and strength, it is conceivable that under certain conditions teas might be improved by manuring. At any rate such harmful effect as may result from manuring is certainly so slight that in practice it may be disregarded, providing manuring is not grossly overdone. It would need a very greatly increased price to com-

pensate for the loss in crop which would result from cessation of manuring.

The usual time for application of manures is in the early spring, following pruning, and the usual practice on mature tea is to broadcast the manure and turn it in with a very light hoe. It takes roughly about 5 weeks from time of application before the bush shows any response to manuring in the spring, and then only if the soil remains moist. If the soil is dry at the time of application, its effect on crop will come about 5 weeks after the first good fall of rain. Thus in general, manures applied in March will be producing a response by the middle or end of April. Some fear has been expressed that the effect of this plentiful supply of available nitrogen will be to produce very rapid and vigorous growth, not only during the first but also during the second flush, thereby seriously affecting quality during this period. Experiments carried out in 1938 indicated not the slightest difference in the value of teas made during the second flush period from bushes manured in March, compared to bushes manured with the same mixture in early October. Moreover, it makes no difference to second flush quality whether the manures applied are in organic or inorganic form.

Nitrogenous manures such as calcium cyanamide which lower soil acidity, have been shown to be less efficient in the long run than manures which increase acidity of the soil. This probably explains the fact that the teas made from bushes which have had calcium cyanamide for some years are slightly better than those which have had sulphate of ammonia. The crop from areas manured with the latter manure is at a considerably higher level than that from the former.

We have been unable to prove any significant difference in quality from alteration of soil acidity by the use of lime or sulphur though there were indications that quality was adversely effected when the soil acidity was brought to a very high level, by large applications of sulphur to an already acid soil.

Early in our work, we tackled the question of the effect of potash and phosphatic manures on tea value, and found indications of a slight good effect from phosphates, and a slight but definite bad effect from potash. The slight good effect from phosphate was so slight that it did not appear to justify the continued annual application of phosphates.

It may be that the long continued omission of potash and phosphate from a manuring programme may in time result in a deficiency of these minerals in the soil and cause loss not only in crop but in quality. The position is being, and will continue to be, carefully watched on our trials at Borbhetta, Tulsipara, and on commercial gardens; and it is confi-

dently expected that ample warning of any falling off in crop and quality will be given, if it does occur.

Pruning.—Results of experiments leave little doubt that the best time for annual top pruning is early December, taking into consideration crop, quality and health of the bush. Earlier pruning, *viz.*, October, gives more and better second flush tea, but autumnals are lost and bushes may suffer more branch disease (sunscorch, etc.), than bushes pruned later. Later pruning than December, though it may lessen the loss from Red spider attack, gives less crop—especially second flush, and does not result in better quality at any time of the year.

There are few gardens indeed where the bulk of the pruning is finished earlier than the beginning of December though there are a few in the fortunate position of being able to make their crop with a lot to spare. Some of these have adopted the practice of pruning early and getting a large second flush crop, afterwards leaving the areas out of plucking.

Clean pruning, by which is meant, (apart from removal of snags and dead wood), the removal of unproductive live wood only, *e.g.*, banjhi and very weakly shoots, has given better quality throughout the season, than cut-across pruning. No better quality has resulted from any more drastic form of clean pruning, *e.g.*, spacing or stick-pruning. This is contrary to Upper Assam belief and should be confirmed on a larger scale by experiments on gardens, especially those in Upper Assam.

We have shewn that bushes pruned biennially give poorer tea than annually pruned bushes, not only in the unpruned year, but also in the pruned year, when pruning is on 2 year old wood. So far, however, we have not been able to carry out experiments on loss of quality resulting from cutting back, but an experiment has been designed to be carried out this year and subsequent years, on tea cut to 8 different heights from the ground in December, 1938. There was no point in manufacturing teas from these bushes in 1930 as no one is interested greatly in quality in the season immediately following cutting back.

Plucking.—We have examined the effect of variations in plucking on quality from two points of view, that of coarseness or fineness of leaf plucked; and of degrees of severity of plucking, maintaining a constant standard of leaf plucked.

In the seasons 1934, 1935 and 1939, the finer the plucking the better the tea. Little difference in valuation, however, was shown between very fine and ordinary fine plucking. A medium form of plucking, which involved taking everything ready (larger than one-and-a-bud shoots) in 7 days, generally gave distinctly poorer and less tippy teas, while the

difference was accentuated with coarser plucking. During the early second flush, however, when shoots were small and stunted by greenfly, and teas reached a high level of quality, it made little or no difference to valuation whatever the coarseness of plucking. There would appear to be no advantage in maintaining a very fine standard of plucking under these conditions, though it might be difficult in practice to persuade pluckers who had been allowed for a period to take everything, to revert to a strict discrimination as soon as the situation demanded it.

In all three years when the experiment was tried, it was found that, had the teas actually fetched the prices they were valued at, freer forms of plucking would have paid in view of the larger crop and lower cost of plucking, provided the teas were kept free from stalk. Unfortunately the experiment is on a block of tea which always gives poor quality relative to many other areas at Borbhetta. With better quality jat, differences due to fineness of plucking might well have been accentuated.

Some of the most interesting results have been obtained in connection with experiments on the effect of severity of plucking on quality. Generally, it appears to make no difference to early teas, and only a slight difference to mid-season teas, whether bushes are hard or light plucked. Light plucked bushes do however give slightly better mid-season teas, and distinctly better autumnals. Thus the same second flush quality results from plucking to the janam over 4″, 6″ or 8″ of new wood. Towards the end of the season, however, the longer new growth results in slightly more autumnal character. Rains teas, and to a more marked degree, autumnals, are improved by leaving a leaf above the janam, on the second round or subsequently. Further experiments are needed to determine the best time to leave this leaf. It is reasonable to suggest that it might be done after the second flush has been removed, *i.e.*, middle to end of July. This is also to be a subject for experiment in the near future, but is also a subject which needs investigation by managers on their gardens. I suggest that a comparison of the crop and quality of tea might be made, between (*a*) the normal system of plucking, and (*b*) one in which the initial growth left at tipping is 2″ less throughout the second flush; and about the middle or end of July a leaf is left on one plucking round, after which plucking is again to the janam for the rest of the season. Thus a garden plucking to 7″ and to the janam, might experiment with plucking to 5″ and to the janam till the end of July, then leaving a leaf for one round, and then again plucking to the janam.

It is not considered an easy matter on some gardens, to establish a new flat surface for plucking, after leaving a leaf. In these cases it may be found better to leave the area unplucked for one round and then to tip to a new level 2″ above the old, or to lightly skiff off the growth 2″ above the old level.

Most of the effects of various cultural factors to which I have referred have been comparatively slight, as far as quality is concerned, though their effects on crop are often very great. Frequently slight improvement in quality could only be obtained at the expense of so much crop that the net result in general would be monetary loss. There is one direction, however, in which very large differences in tea characters show up and that is when we are concerned with jat. The subject is, however, one for the botanist. After we had manufactured crops from several well-known commercial jats and found large differences between them in tea value, the botanist showed that there were even greater differences between individual bushes of the same commercial jat.

It is well-known that there is no such thing in commercial tea as a pure line variety, and that the product of any seed garden is mixed. Under such conditions experiments made to compare the quality of teas of different jats is liable to provide misleading information unless it is clearly understood that results strictly apply only to the particular areas of tea on which the experiments were made. Nevertheless results do provide in a broad way some indication of relative characteristics and merits of distinctly different commercial jats.

I have said enough to indicate that our knowledge of the effect of cultural factors is comparatively small, in spite of 8 years of concentrated work in this direction. Moreover such results as we have obtained must be applied in practice with caution.

There is a great need for a translation of these results to garden conditions, by carrying out experiments on a full scale plan. We have attempted to carry out experiments on a small scale in commercial factories, but results are not so far encouraging. We are still hoping to devise a small scale method which will be applicable to gardens.

I am of the opinion that at the present time the small plots designed for experiments on commercial estates are not suitable for providing material for manufacture—even by combining the leaf from 5 replicate plots of 200 bushes each, one cannot get enough leaf to fill a large roller.

Larger areas are necessary, but it is obviously not practicable to lay out a complete N. P. K. experiment, for instance, with one acre plots. It would be possible however for each of 5 gardens in an Agency or Company to lay out a limited number of five acre plots and give each its appropriate treatment. By combining the results of all 5 gardens, some approach to accuracy can be obtained.

A point of great interest in Darjeeling for instance, would be to find whether phosphate, which has improved quality slightly in our experiments, would do so to a greater extent, and one which would make its

application worth while. An area of say 10 acres of the same jat might be chosen and half of this area given phosphate. Weekly manufacture of the two areas could be made over the second flush and the teas sorted and valued. As a precautionary measure the areas should be plucked and manufactured separately during the season before applying the manure to see whether approximately the same flavour, etc., is given by both areas. If this experiment were carried out by five gardens, the combined results should be of value.

The Dooars are concerned with loss of autumnals—it would be of great value to determine in the same way as I have described above, whether closer initial plucking, followed by leaving a leaf, would effect an improvement in autumnals sufficiently marked to be worth while.

It is no use one garden doing an experiment such as this on a single area. Either it must be done by several gardens on exactly similar lines, or one garden must repeat the experiment on several large areas.

Mr. Burton wanted to know with regard to experiments on commercial gardens how big plots could be used. He had tried plucking experiments when the leaf was rolled in the same roller at different times. The experiment was therefore not precise.

The Chairman said that this sort of experiment could be properly designed statistically, and it was important first of all to consult the Scientific Department, as it was by no means a simple matter to eliminate sources of error and make such an experiment as far as possible above criticism. We knew that tasters could distinguish between the teas manufactured in our own rollers, which were purchased as identical. Large rollers must similarly differ slightly, and differences between rollers must therefore be allowed for. However, it was possible to design efficient experiments, and the Officers at Tocklai would be only too pleased to assist managers in so doing.

Mr. Harrison stated that an experiment had been carried out on a commercial estate comparing tea manured with phosphoric acid, with unmanured tea. The two samples were rolled in a single roller. In one week the phosphoric acid—manured tea was rolled first, followed by the unmanured tea; the next week the order was reversed. If sufficiently replicated in this manner such an experiment was satisfactory, otherwise the best method might be to have one replication of each treatment on each of several gardens in a district, possibly of the same agency or the same company. The final working out of the experimental results could be done at Tocklai.

Mr. Burton said that he could undertake one such replication but Mr. Harrison pointed out that Mr. Burton could only do one repeat and

the point was that many replications would be needed for each experiment. 4 or 5 gardens in one vicinity would be the minimum.

Mr. Cooper emphasised that in experiments with a single replication the different plots might be on entirely different soils. This did not apply to Mr. Burton's experiments in which he had compared the bulked leaf from 7 plots with the bulked leaf from 7 other plots. In this way error arising from soil differences certainly was made very small though we could not estimate its amount as we do in our other experiments.

Mr. McLennan asked how the difference between the two rollers at Tocklai could be accounted for.

The Chairman pointed out that it was extremely difficult if not impossible to obtain two machines which could be guaranteed to produce exactly the same effects on the material passing through them. Thus the two rollers in the Tocklai Experimental factory, though of the same make produced very different results even when run at the same speeds, pressures, etc.

Mr. Boyle considered that an investigation of the causes of such differential effects would be well worth while.

Dr. Roberts mentioned that he had been using boys to roll 2 lbs. samples of leaf by hand. Differences in pressures applied by the different boys were very obvious. This was overcome by making each boy roll each sample for a short period.

The Chairman remarked that the Conference would appreciate in some small measure our difficulties in designing experiments on this account.

Dr. Wight pointed out that the differences between our small rollers were likely to be much greater than between full sized rollers.

Mr. Winter added that in a similar way differences between single boys each rolling 2 or 3 ozs. of leaf were greater still.

Dr. Wight stated that particularly when small quantities of leaf were being handled, as in the Botanical Laboratory, there was an unavoidable tendency to even out differences between various samples by the carrying over of juice on the boy's hands from one sample to another.

Dr. Roberts stated that in spite of this, the differences between the various samples still remained very marked, when 2 or 3 lbs. samples were being rolled.

Dr. Roberts stated that he had seen it mentioned that phosphorus had an influence on flavour. He was inclined to a theory that phosphorus manuring and high altitudes were both necessary for the production of flavour. Could Mr. Evenden tell the meeting whether there were any indications of more flavour in second flush, high altitude, teas which had been manured with phosphorus.

Mr. Evenden answered that he had never heard phosphorus connected with quality. He considered that this was a matter for experiment and he hoped that the Darjeeling District Advisory Officer would take up this line of work.

Mr. Burton noted that greater nett financial return was obtained for coarsely plucked teas than for finely plucked teas according to the Tocklai taster's valuations. It would, he thought, be dangerous to forget that we were now working on a restricted market.

The Chairman emphasised that with the Restriction Act in operation it does pay to make the best tea we can, so long as costs are thereby not unduly increased.

Mr. Harrison observed that the results of experiments could only be taken as indications. It was essential to check findings under local commercial conditions.

Mr. McLennan pointed out that this year teas would undoubtedly be marked according to whether their valuation was up to standard or otherwise. If they were not up to standard they would not of course be accepted. Would plucking more freely in the second flush tend to lower the standard of the tea? He also enquired whether tasters would notice the difference brought about by freer plucking.

Mr. Cooper thought that tasters would recognise more coarsely plucked tea. He recommended taking all leaf that was ready, at times when the growth was stunted. As soon as the flush came away, about 1st June, then plucking should be kept fine. While the stunt was on there was no point in rejecting very small shoots of 3 leaves and a bud.

Mr. McLennan suggested that in that case it would be better not to alter plucking at all.

The Chairman pointed out that the difference due to stunted leaf would alter the value of the tea over as short a period as a fortnight.

Mr. McLennan stated that in that case only one invoice would be affected.

Mr. Harrison wished to emphasise that our plucking experiments had been done on poor jats. We did not know what would happen on better quality tea but very probably bigger differences would be noticeable.

Mr. Cooper said that one must not forget the differences in quality which had been found between the jats. It would be a long time before our selection work produced pure line varieties on a commercial scale, and meanwhile it was of great value to a planter to have some idea of the quality and crop to be expected from the commercial jats he intended to use for replanting.

Dr. Wight agreed, but said that his criticism of our present manufacturing experiments was that it would be unwise to argue from a single comparison of light and dark leafed jats, to light and dark leafed tea in general. It would be dangerous to generalise from our admittedly limited jat plantations at Borbhetta and Tocklai.

Mr. Cooper said that though he agreed with Dr. Wight concerning undue generalisation, we were entitled to say that certain jats with which we have experiments would do well but others would not.

Dr. Wight rejoined that in dealing with commercial jats we took the seed from the tree 10 years before the results became available. In the meantime great changes might have taken place in the baries from which the seed came. Our plants represented the seed of 15 years ago, and not necessarily that being sold at the present time under the particular jat name. Caution was therefore necessary in applying our results to present-day commercial jats. In some cases the characters were persistent, in other cases they might not be.

The Chairman said that the Conference would appreciate the difficulties encountered in this connection. Dr. Wight had manufactured separately thousands of individual bushes of different jats. He had found tremendous differences in the tea even from a single jat. One particular bush producing really good quality tea was a dark leafed Manipuri. In the main this jat did not give good quality tea, and there were thus obvious possibilities of altering entirely the characters of the present jats. When crop was increased by manuring it was usually found that the quality fell off to a certain extent. Nevertheless when dealing with individual bushes within a jat, high quality bushes had been discovered which were also good yielders. It was not necessarily true that a high-yielding bush was always a poor quality one. Taking an individual bush whose characters are known, a high yielder and high quality, it was possible that further increasing the yield by manuring would lower the

quality. At the same time there seemed to be no reason why high-yielding bushes of high quality which were not appreciably affected by manuring, might not be obtained by suitable selective methods.

Tea tasters had insisted that we were not now making as good quality teas as were made in the old days. This was particularly noticeable in the case of autumnals. The Chairman thought the modern plucking, hard on to the jaunm, had a great deal to do with this. We had indications that autumnal flavour could be affected by such plucking. The claims of the tasters, as with all reminiscences, were probably exaggerated to a certain extent, but he thought that the present day lowering in quality was by no means completely imaginary.

Mr. Evenden suggested that experiment on variations in quality of tea resulting from manuring be conducted both on good and poor quality bushes. He hoped that the Advisory Officer would carry out experiments on any possible loss of quality brought about by manuring in Darjeeling.

Mr. Scott asked whether loss in quality due to manuring occurred throughout the season.

Mr. Harrison pointed out that whether the plots were manured or not there was the same difference in autumnal flavour with the different plucking described. The experiments on manuring had been carried out both on good and poor jats.

Mr. Scott said that there was an idea in the Dooars that the seasons were changing, particularly in regard to the late rains. Could this be the reason for the loss in present-day quality mentioned by the Chairman?

Mr. McLennan said that owing to Restriction, gardens were stopping plucking earlier in the year. He remembered plucking on Christmas day, when autumn flavour was obtained.

Mr. Harrison said that the loss in quality complained of by the tasters was noticed before Restriction came in. In the Dooars they still made as much autumnal tea as possible and sacrificed poorer quality rains teas.

The Chairman said that he wished to bring to the notice of the Conference the Tocklai taster's Report Form which differed from the forms used by tasters for muster samples. He passed round the Taster's Form, pointing out the extreme detail of the terminology used. The taster had to decide into which category of a comprehensive series any particular property of the tea fell. This use of detail enabled comparisons between experimental teas to be carried out with much greater accuracy, and provided data very suitable for statistical examination.

Dr. Wight brought up a further point about Taster's Forms. By studying a large number of reports from the same taster it was evident that the tasters' own classification of the gradation of a tea character often did not fit in with the groupings on the Taster's Form. It was not possible to standardise all the tasters. We had, for instance, 8 grades of a character. Some tasters could only distinguish 4 or 5 grades. The taster was not consciously aware that he was making use of 4 or 5 grades only.

The Chairman added that the use of statistical analysis of the Forms submitted by a large number of tasters had revealed the unconscious biases of tasters tasting for different markets. The Form had proved of the greatest use in experimental work.

The Chairman then asked Mr. Benton to talk on Water Supplies. Mr. McLennan had asked last year about the pollution and sterilisation of water for tea garden purposes. Experiments had been done in 1939 and the results were of great interest.

Mr. Benton.—Purity of water supply is of importance to all gardens, both from the point of view of manufacture and of the well-being of the labour force. A polluted water supply cannot be used with any degree of safety in a mist chamber, and cases are on record where the use of highly infected water for washing down machinery has led to infected teas. In some districts the custom of washing rollers and machinery during the course of manufacture is becoming prevalent, and the regular washing of trollies each hour during manufacture is generally recommended. An infected water supply may however lead to trouble if used to clean machinery during the course of manufacture, when flaming is not possible.

It must also be borne in mind that a polluted well or tank is an indication that conditions are not as they should be, and although the bacteria normally present in the water may be innocuous as far as human life is concerned, the appearance of a single dysentery or cholera case on the garden may be followed by an epidemic if the water supply is exposed to pollution.

In tea gardens, water troubles come under three main headings, *viz.*:—

Bacteria

Algae

Iron.

I propose to deal with each separately.

I. Bacteria.—*Bacteria may find their way into a water supply in* three ways:—

(1) Direct pollution;

(2) Decaying animal matter;

(3) Decaying vegetable matter.

Direct pollution occurs when organic matter, on which bacteria are developing, is allowed to find its way into the water. In tanks, surface run off is the primary source of pollution. When a tank is constructed, a zone of land of varying width is frequently arranged to slope towards the tank in order to increase the catchment area. In such cases it can be safely assumed that bacteria breeding on cattle manure, and on rubbish deposited on the catchment area will be washed into the tank when heavy rain occurs. Tanks should therefore be fenced, but a fence on the catchment area will not suffice, since cows have a tendency to congregate along a fence; the catchment area should be terminated by a reverse slope at least a yard in width, and the fence should be located on the outer edge of this strip. Small mesh wire should be used at the bottom of the fence to prevent dogs and jackals from polluting the catchment area and the water.

Where water is supplied from the tank to a pump, the pump should also be situated outside the catchment area and beyond the reverse slope, so that the refuse from cooking utensils, personal ablutions, etc., cannot flow into the tank under the influence of heavy rain.

In wells, direct pollution can occur although it may be less obvious. The use of a bucket should not be countenanced, since this may be placed on the ground and may then carry infected mud into the well. A pump should be provided for each well; this should be mounted some distance away from the brickwork, and the well itself should be provided with a locked cover and a wide concrete apron.

It is particularly important to provide a cement surfaced drain to carry away all waste water from the vicinity of the pump and well. During dry weather, surface soil, particularly that which is well trodden, has a tendency to crack to a considerable depth, and these cracks provide channels through which polluted water can find its way into the subsoil and thence into the well, being assisted by the holes left in the soil by various tunnelling insects. It is therefore necessary to ensure that the soil in the vicinity of the well cannot be polluted by the labour while drawing water or washing.

It is also important to see that the inside walls of the well are sealed against leakage through cracks, as far down as possible. Seepage

through brick or concrete is not of great importance since the structure of the material results in the bacteria being removed during the passage of the water, as in a filter-candle. Pointed brickwork is less satisfactory than cement plastering with a waterproofing compound incorporated in the mix. (It should be remembered that when a well has been resurfaced or pointed, the water will have a strongly alkaline reaction for some time, and it should therefore be used with caution in the tea house).

Wells should not be placed near hullahs, and where they are close to factory drains, the latter should be properly faced with cement plastering to prevent leakage into the soil. A case of severe infection has been investigated in which pollution was undoubtedly taking place through factory washings escaping into the soil through cracks in a drain close to a well.

Apart from direct pollution, water may be infected by decaying animal residues. Wells are more likely than tanks to suffer from this source of infection, since rats, mice, frogs, etc., which find their way into the water will eventually drown and decay. A close fitting cover should eliminate the trouble.

Decaying vegetable matter can provide a high infection of bacteria which are undesirable in the factory. In wells, this can be obviated by cement plastering and by maintaining the inside of the walls in a clean condition, free from ferns and weeds. In tanks, bacterial infection may be raised to high figures by two practices which are by no means uncommon, *viz.*, using the side of the tank as a dumping ground for waste leaf from the tea house, and pickling bamboos in the water before use in the withering chungs. The 'pickling' processs is bacterial, and is similar to the retting of jute. A special tank should be reserved for this process.

Sterilisation for bacterial infection.—If a water supply is known to be infected it can be sterilised, but it is first necessary to determine the source of infection. If this is surface or subsoil pollution, sterilisation will have a temporary effect only. When the catchment area in tanks, or the walls in wells have received the necessary attention the water may be treated with E.C. to supply one part available chlorine per million parts of water. Using a product containing 2% available chlorine, one pint of E. C. will be required for each 400 c. ft. (2,500 gallons) of water. The amount of E. C. must be increased for waters rich in organic matter. No danger need be anticipated from the use in the factory of a water treated in this manner.

An interesting form of water sterilisation is now being investigated in my laboratory, which is based on the fact that minute traces of silver

are highly toxic to bacteria. (Katadyn process). The simplest apparatus is required for small scale sterilisation, consisting of a flash lamp battery, two pieces of wire and two rupees. The coins are connected to the terminals of the battery and are then held ¼" apart and immersed in the water. Tests show that if two pints of water are treated in this manner for 15 seconds, sterility is obtained after the water has been allowed to stand for 1 to 2 hours, even when the water originally contained some 10,000,000 lactose fermenters per cc. It should be possible to adopt this technique to large scale sterilisation; it has been calculated that using silver electrodes 6 inches squares, 1,000 gallons per hour could be treated. Typhoid, dysentery and cholera organisms are particularly sensitive to this process.

II. Algae.—It occasionally happens that an exposed water supply develops an unpleasant odour and taste for no apparent reason. At the same time a cloudy suspension appears which does not readily settle. Examination under the microscope reveals the presence of algae in minute flakes and filaments. These organisms are rudimentary plants whose development is dependent on sunlight. Hence the effect usually appears in prolonged sunny periods when rain is in defect.

Filtration may remove the algae but does not improve the taste and odour of the water, and furthermore the gelatinous mass of algae may quickly clog a sand filter, throwing the whole water supply out of operation.

Investigations carried out in the past year show that two methods are available for effectively dealing with this trouble. Algal development may take place in one of the small tanks used for storage, filtration or sedimentation, or in the main supply tank. In the former case, the problem may be attacked through the metabolism of the algae, which are unable to develop in the absence of strong light. It has been found that if the tank is covered in such a manner as to exclude sunlight, the condition rapidly clears up without further treatment, although it is advisable to clear the water with lime and alumino-ferric to prevent clogging where sand filters are used.

If the infection is developing in a large open tank, use must be made of the fact that algae are peculiarly sensitive to very low dilutions of copper salts. One ounce of copper sulphate to each 1,000 c. ft. of water will destroy the algal growth. The immediate result of this treatment is that the oil sacs in the algae rupture on the death of the organism, and the taste and smell of the water become temporarily very much worse. The released products are, however, rapidly destroyed by bacteria and the condition may be expected to clear up within ten days, during which time

an alternative supply should be arranged. Clearing with lime and alumino-ferric completes the process.

III. Iron.—The presence of iron in water supplies provides one of the major problems of the industry. Subsoil waters in this country frequently contain large amounts of soluble iron in the ferrous condition, which on exposure to air, becomes oxidised and precipitated. Filtration will not remove the iron unless it has been completely oxidised, hence one finds cases where freshly filtered water becomes turbid within a few hours.

The only satisfactory treatment is to provide aeration and settling tanks which can be cleaned at intervals. Aeration may be secured by discharging the water from a height into the tank, or by allowing it to fall over a series of baffles. Sedimentation can be brought about by providing a series of tanks connected at the top, and large enough to secure a slow passage of water. The settling tanks should be duplicated and provided with drain plugs for cleaning. Sedimentation of the oxidised iron is assisted by the use of lime and alumino-ferric.

Clearing water supplies.—When finely divided organic matter or Iron is suspended in a water, sedimentation may occur too slowly to be of any practical value. It may, however, be assisted by the use of alumino-ferric or alum. Briefly the process consists of forming a precipitate of hydrated alumina in the water, which sinks to the bottom carrying with it suspended matter and bacteria.

The process is dependent on the presence of sufficient bases in the water to precipitate the alumina, and since most water supplies in the tea districts are acidic in character, precipitation usually requires the addition of lime. Quicklime is mixed to a cream with water and distributed throughout the supply. The alumino-ferric or alum is placed in a bag, attached to a raft and dragged through the water until dissolved. Alumino-ferric is usually employed at the rate of 4 to 8 lbs. per 1,000 c. ft. of water. Lime is required in sufficient quantity to bring the water to the neutral point (green to Brom-thymol Blue) but a reasonable excess may be added with safety.

Mr. Comrie said that the use of alumino-ferric in the Tocklai water had clogged the pump. The pump was cleaned by means of hydrochloric acid and the deposit probably contained lime, or the result of the interaction of the alum and lime.

Mr. Macgregor observed that the use of too much lime killed the animal life in the water with an obviously bad result.

Mr. Boyle considered that the experiments described by Mr. Benton should undoubtedly be continued.

Mr. Scott agreed that the sterilisation experiment in particular should be continued as it would be of a special value to gardens with a hill supply.

Mr. Benton observed that he wished to try out the method on a garden scale.

Mr. Scott offered to carry out the experiment on his garden.

Mr. Benton observed that the cost of such a sterilisation installation would be about Rs. 50/- for the battery and Rs. 50/- for the necessary silver plates.

Dr. Wight asked, in view of the war, what would be the position with regard to the German Katadyn patent specification.

Mr. Burton asked whether it would be possible to make use of the current at 110 volts.

Mr. Benton observed that low voltage and low current density seemed to be essential but that use could be made of 110 volt supply by means of resistances.

Mr. Tunstall suggested that resistance could be brought into the system by having the electrodes further apart.

Mr. Macgregor considered that it would be better to keep any adjustment of the voltage independent of such factors difficult of control, as the conductivity of the water.

Dr. Wight observed that the ancient Egyptians considered that the storage of water in silver vessels sterilised it. He observed that certain weeds were harmless in water supplies whilst others brought about the greatest difficulties. A certain weed which resembles thatch at the bottom of tanks, both clogged the tank and polluted the water. There was a note concerning this weed in an issue of *Current Science* in 1937. The only way to keep the weed under control is to pull it out by means of drag lines. In connection with the desirability of certain weeds in tanks he observed that liming tanks would probably upset the desirable plant-life as much as the undesirable.

Mr. Benton stated that the balance of life in the Tocklai large tank has been upset by repeated cleaning of the bottom, while the water in a nearby undisturbed tank was much cleaner.

Dr. Wight observed that the big tank supported a large annual growth of weeds while the other tanks kept clean of their own accord.

Dr. Roberts observed that in connection with recent experiments on oxygen fermentation it had been found necessary to mix water vapour with the oxygen passed into the leaf in order to get over the drying effect of the gas. The peculiar results of some of the experiments might possibly be explained if the water used had not been perfectly pure. In our own experiments with oxygen fermentation we had used distilled water.

The Chairman said that there had been some inexplicable results obtained with that process, possibly this was the explanation of some of them.

The Chairman then called upon Mr. Tunstall to address the meeting on Nursery diseases.

Mr. Tunstall.—

The condition of the seed before germination sometimes causes poor growth in the early stages of tea nurseries. The commonest defect in seed is caused by undue loss of moisture before planting. This causes the cotyledons to shrink from the seed coat and thus allows room inside for the young shoot to grow inwards. The consequent distortion of the stem hinders free growth.

Conditions in the nursery bed are more often responsible for distortion of the roots, thus leading to restricted growth. Bent roots are less common than bent stems. Sticky soils sometimes cause bending by preventing the movement of the seed but more often they cause distortion on account of the lumpy condition of the seed bed.

The most frequent cause of poor growth is irregularity in watering. It is better to give the beds a good soak once in a while than to sprinkle them at more frequent intervals.

On soils which form a surface crust under heavy rain, tea seedlings are very often attacked by fungus disease at or near the collar. More than one kind of fungus does this. The commonest is a species of *Phomopsis*. *Pythium* sp. also do the same kind of damage. The fungi concerned kill a ring of tissue thus cutting the roots off from their supply of the substances prepared by the leaves. The woody cylinder which is concerned with the upward flow of sap is unimpaired. If there is a certain amount of reserve stored up in the root the damaged seedling continues to grow as if nothing had happened. Often a ring of callus is formed

above the injury. Sooner or later the root dies for want of energy supply and the plant fades away. This kind of damage can be palliated by protecting the collars of the young plants with a coating of 1% Burgundy or Bordeaux mixture. The surface crust should be broken up before the spraying is done. The best time to make this application is just before the heavy rains commence.

In recent years it has been increasingly necessary to plant nurseries on land which had been cultivated previously. Such land is very commonly severely infected by eelworms (*Heterodera marioni*). On uncultivated land these eelworms are not very common and are generally confined to small areas. Cultivation tends to distribute them. We have tried all the substances recommended or suggested in the comprehensive literature dealing with this world-wide pest. No poison has been found sufficiently effective to warrant its practical application. We have found the best results in the reduction of the numbers of plants infected, to follow the burning of 1 foot thickness of dry jungle on the surface of the beds before planting. In our experiments this only gave a reduction of 10%. The greatest effect in palliating the damage from eelworm was obtained by shading the plants. When it is necessary to plant tea nurseries on cultivated land it is well to dig out and remove all herbaceous weeds with all their roots Most of the eelworms will be removed in this way but the eggs will remain. If the roots are rinsed in water the nodules formed by the eelworm may be observed. Any portion of the site which appears to be heavily infected may be excluded from the area. The stunting produced by eelworms does not usually become apparent until infection has become very severe. Badly infected plants do not resist dry weather conditions and very soon show signs of wilting in periods of hot dry weather.

It may be mentioned briefly that spray fluids also exercise a stunting effect but this is only temporary and the plants soon recover.

Mr. Harrison said that a common type of tear gas was a white solid which had to be heated in order to produce the noxious vapour. Could it not be hoed in as a solid and heated in the soil by burning jungle on the top. There should be no difficulty in obtaining this substance.

Mr. McKay asked if line manure could infect tea with Eelworm.

Mr. Tunstall stated that although there were many eelworms in cattle and line manure they were not the species which attack tea. At one time gardens were warned about using cattle manure on nurseries for this reason but we now considered that no ill effects would be brought about from this source.

Mr. Evenden suggested that cattle manure be heated before application.

Mr. Tunstall considered that there was no need to do this.

Mr. Macgregor suggested that it might be possible to sow a trap crop on the nursery site with the tea in order to attract the eelworms away from the latter until they had reached the age of immunity. This crop could then be removed and burnt.

Mr. Tunstall stated that as part of another experiment, some cowpeas had been carefully dug up and found to be infected heavily by tea eelworm. There was no relation between the intensity of infection and the manures which had previously been applied to the area. The nursery which was afterwards put out on the site was found to be practically free from infection. This trap crop had undoubtedly taken out the eelworms. Similar experiments had been done in many centres throughout the world but the idea had been given up because it was essential to uproot the crop at exactly the right time. This was extremely difficult to estimate in practice, and if not estimated exactly, eggs would be left in the soil and the infection would be greater than ever.

Dr. Wight said that there was some evidence in favour of certain types of twisted stems of seedlings being heritable, quite apart from the induced twistings. This was a subject which might be worth investigation.

The Chairman asked that in this connection details of the source of the seed always be given when specimens of such seedlings were sent to Tocklai.

Dr. Wight said that extraordinarily twisted stems had been found on mature bushes. They had no fungus in them and the twisting was probably inherited.

Mr. Pearson recognised some of the specimens as coming from his garden. They had been found only in one nursery, while the same seed in other nurseries had given perfectly normal plants. On one of his gardens he had a tea bush with all the branches twisted.

Dr. Wight said that a sample of seed from that bush would be of great interest.

The Chairman mentioned that less damage from eelworm had been found on nursery plants when the nurseries were shaded. The nurseries at Borbhetta were not on jungle soil but had been grazing land for many years and did not suffer from eelworm; they were always put out under

shade. It was essential to shade such areas when used for nurseries. The Chairman stated that on many nurseries, cases of stunting and bad growth were due to under-acid soil. In cases of doubt it was essential to take soil samples for acidity tests. It was better to be on the safe side in this respect quite apart from fungi or eelworms. The Department could inform the garden concerned how much sulphur was necessary to bring the acidity to that required by tea. Young tea was even more susceptible to under-acid soils than mature and established tea.

The Chairman then called upon Mr. Cooper to talk on Replanting.

Mr. Cooper.—Three questions from the Terai on this subject concern: —

(1) The treatment of the plant before planting, e.g., pruning in the nursery.

(2) The treatment of the land before planting.

(3) The treatment of boga medelon growing among the young tea

To none of these questions can we give either a short or a conclusive answer, since no accurate experimental work exists on the points at issue. They are, therefore, very suitable subjects for discussion. In each case, after giving opinions based upon all the evidence we can find, we shall be very grateful for the results of the experience of members of this Conference.

Like the others from the Terai, Question 9, dealing with the pruning of nurseries, is a very complex question.

In the first place it assumes that plants *must* be pruned in the nursery.

The evidence is clear enough, in the case of nurseries up to a year old, to allow us to give advice as to when they should be cut: like Mr. Punch's advice to those about to marry, "Don't". We have seen pruning of young nurseries tried several times. The result is many deaths, and the deaths are heaviest among the best plants which have been growing strongly and exhausted their reserves. The plants which survive have been without leaves for a large part of the growing season, and are consequently much smaller and weaker than if they had not been cut.

This same consideration does apply to older plants; but it is both expensive and very difficult to carry tall plants without damage. Older

plants, too, have more reserves in the roots and stand cutting better. Having been cut low in their nursery, they do not again have to be cut low as tall plants would have to be: hence, on those which grow strongly after planting, about a year is saved; and they can grow strongly after planting, if they are full of reserves at the time of cutting.

Pruning in the nursery then may be desirable on old plants, although objectionable on young plants, and the question becomes whether we should use young plants or older ones.

The evidence on this point is so indefinite that two big agencies have come to opposite conclusions. One very strongly discourages the use of any plant less than two years old, while the other just as definitely objects to the use of any plant older than eighteen months. Each is satisfied that its order is justified by its experience, and both have gardens in the same districts. Each can show excellent results. Each in fact, proves the other wrong. Each *is* wrong: nurseries can be used successfully at any age, if the plants are good enough, and not too big to be hopelessly expensive to carry.

No general rule can be laid down on the best age for planting.

Our experience here causes us to favour plants about a year old for planting or replanting. We think the time of year favourable; and the smaller plants are much cheaper to plant, and easier to plant well, than bigger plants.

On the other hand, some nurseries have miserable plants at a year old, which with manuring can be quite good at two years old. In the more severe climates, like the Terai, the older plants have more reserves in the roots, and are less likely to die after planting. It is much easier to select good jats from among the older plants. Even for this district, we are inclined to favour two-year-olds for infilling; but in that case we should plant uncut, and cut only when satisfied that they are well established, which generally is one year later.

The chief difference is in cost of planting, and we think that nurseries generally should be good enough to plant cheaply and well at a year old. If they are not good enough, one should wait: while it is much cheaper to use existing nurseries of even four years old than to abandon them, and grow new nurseries. The extra cost of using old plants is not all loss: they come on very rapidly.

The question however takes as example, nurseries between 2 and 4 years old which are to be planted in mid-May. These have to be cut, and advice is asked on the best time for this cutting. In answer we can only

give reasons on which an opinion may be founded. Such an opinion may be found quite wrong when tested by experiment, because some unsuspected factor may be operating. Our experience here, on this point, is concerned only with cold weather planting. At that time, to prune and plant at once does well: but we have had better results from old nurseries, from cutting so that the new growth is again dormant at planting time. The safest time for this is the previous cold weather: cutting during the growing season may be very successful, but is attended by risk of a considerable number of deaths. Another very successful method is to cut just in time to get buds formed, but not broken to show green, at the time of lifting.

In the case under consideration, when planting is to be in May, I think the first two methods are ruled out. Mid-May in the Dooars and Terai is very close to the peak of the second flush, a time of very vigorous growth, unless drought has been very severe and prolonged. I should not like to cut in mid-May, and it would be extremely difficult so to time the cutting that growth was banjhi in mid-May. My opinion then is that it will be best to try to get buds formed, but not broken, in time for the planting.

I think it likely that this object would be achieved, if the cut were made when plants are banjhi after the first flush. This would be, generally, about the second week in April; but nurseries will have to be watched, and planting started when the right stage of bud-swelling is reached. If this, in early seasons, should mean starting planting before mid-May, I am inclined to think that results would be all the better.

In regard to Question 6 on Replanting, which reads as follows:—

"The custom here is to prepare the land 12 months previously by uprooting the bushes in the early spring (Feb./March) then to sow a green crop of mixed medeloa and arhar: this is allowed to grow until Jan./February in the following year. It is then cut down and hoed in. We find that when we start planting, this crop gets in the way of the men digging holes for the plants.

"Tocklai recommend that this green crop should be cut down and dug in during Sept./October of the year it is sown.

"It is recognised that the hot sun is an adverse factor on land lying without cover during the hot weather months: also a green crop does not begin to give back to the soil any benefit until it has seeded.

"When do you consider is a suitable time to cut down this green crop: in September it has not reached maturity therefore is still a drain on the land, in February it has seeded and is giving back to the soil its nitrogenous elements, but the stem developments are not reduced to humus before the planting (May/June) commences."

This question brings forward objections to the application, under the conditions of the Terai, of Tocklai's general recommendations. These objections are based upon two hypotheses:—

A. A green crop does not begin to give back to the soil any benefit until it has seeded.

B. The hot sun is an adverse factor on land lying without cover during the hot weather.

A. Any nitrogen fixed from the atmosphere is still locked up in the leguminous plant, until it has either dropped leaves, or attained maturity and started to break down.

When, however, we cut down and hoe or plough the plants into the soil, any nitrogen already fixed from the atmosphere is returned to the soil by force.

I can find no evidence regarding any difference in efficiency of fixation at different stages of growth: but it is known that, if the necessary nodule organisms are present, a legume can be grown in a soil devoid of nitrogen and is therefore capable of taking from the atmosphere all the nitrogen necessary for its growth, from the time the nitrogen in the seed is exhausted. It has in fact, been shown that nitrogen fixation begins at the time the first leaves appear.

While, therefore, we should expect a greater gain of nitrogen by leaving the plant to attain greater size before turning it in, there is no reason to expect no gain of nitrogen if we turn the plant in after six months growth, when it is approaching maturity and would soon flower.

B. The hot sun.

This subject came under discussion at the Conference of the Tea Research Institute, Ceylon, on the 13th and 14th February, 1939. "Mr. M. L. Wilkins asked whether exposure to the sun had any effect on soil. He referred to the recent mania for composting prunings, a practice which left pruned areas denuded of cover for at least ninety days. Dr. Harler in a lecture in London, in September, 1937, had emphasized the importance of protecting soil against harmful sun effects."

"Sir John Russel commenting on the very interesting observation, remarked that he would be glad later to have more information on the subject. The facts about sun effect were rather obscure. There was very little experimental work except Prescott's in Egypt and there exposure was found to be entirely beneficial, but the circumstances were quite different from those in Ceylon. In Egypt there was a certain amount of salt deposited in the soil and Prescott showed that the effect of the sun was to open up the soil in such a way as to allow the salt to be washed out. There was also a partial sterilisation effect which increased the available plant food. On the other hand, in the Sudan the work on sun exposure showed that sun destroyed nitrates in the soil and nitrates were the most readily available of plant foods. In the Fenland in England farmers declared that a summer bare fallow was bad treatment of the soil and reduced its productiveness. The difficulty of getting a decisive answer arose from the fact that when soil was covered it was very likely enriched. For instance a cover of growing green manure was obviously an advantage to soil fertility. To get a definite answer some way of shading soil without attendant fertility effects would have to be used in comparison with bare land.

"Mr. P. A. Keiller said that he had read an account of laboratory experiments that claimed to show a definite loss of nitrogen from a block of soil with no vegetative covering, exposed to ultra violet rays. The author made a strong point of the loss of nitrogen from tropical soils owing to sun exposure. In reply to a question, Mr. Keiller said the book was Corbett's 'Biological Processes in Tropical Soils.'

"Sir John Russell in reply said that opposed to this was the work of Dhar in India who maintained that exposure to sun could increase the nitrogen in a soil. The experiments in the Sudan that he had quoted were very carefully carried out, but work of this nature was very difficult to do. When he had visited the Sudan he had found that, notwithstanding the care devoted to them, these investigations were capable of being criticised. This question of the effect of sunlight would be worth taking up in well devised experiments. One thought at first sight that a clear cut answer ought to be obtained, but so far a really critical experiment was wanting. The Tea Research Institute would be a suitable place if the staff had time."

It must be noted, therefore, that it is *not* "recognised that the hot sun is an adverse factor on land lying without cover."

There is nothing in our experience which lends the slightest support to the idea that sun does any harm whatever to our exposed land. On the contrary we think that it does good, though we have no direct proof that this opinion is correct.

We do know that we get our maximum nitrate concentration in the soil very soon after rain first falls on soil which has been warmed and dried in the sun, and that plants consequently flourish, if they have not suffered too severely from drought.

Sir Albert Howard in 1910 reported, in "Nature", that it has been the practice for centuries past among the best cultivators in the Indo-gangetic plain, to expose their soils to the intense heat and light of the Indian hot weather in April and May and stated that "the beneficial result on the succeeding crop is extraordinary, and has all the effect of a nitrogenous manuring." Howard ascribed this effect to the partial sterilization of the soil, good effects from which had recently been proved by Russell and Hutchinson at Rothamsted.

The introduction of a bare fallow on the heavy clay soil of the permanent wheat plots at Rothamsted was followed by remarkably good effects. These plots had been extremely weedy, and weed-destruction may have contributed to the observed good effect in this case.

Harrison is repeating and extending the work of Dhar, in this laboratory, using our soil. I must not anticipate the completion of this work; but I may say that, in the course of it, Harrison has found very much greater *increases* in the total nitrogen content when the soil is exposed to the sun, than when it is kept either in the dark, or in diffused daylight.

We know also that we have, in parts of Assam and of the Surma Valley, soils with so much clay that they would never be under arable cultivation in Britain, particularly as they contain extremely little lime; yet, even with high rainfall, they do very well under tea, if they get enough nitrogen. We are very much inclined to think that the drying these soils get in our "cold" weather is a big factor in keeping them in good condition. Nothing is more effective than successive drying and wetting in improving the "tilth" of a normal mineral soil, so that it becomes more friable and more permeable, and breaks down more readily into a good seed bed.

On the other hand I think the Fenland farmers in England also to be right in their dislike of exposing their land to the sun. These Fen soils are humus soils very like our bheel soils. The process of alternate wetting and drying which we think so good for normal mineral soils, and particularly for clay soils, renders bheel soils too loose and friable, so that after many years they lose all "binding" power and are aptly described by planters as "fluffy".

It is not a case of loss of humus, but of change in physical state: bheels in highly productive condition show no distinguishable chemical

difference from infertile "fluffy" bheels. Soils with much clay, however rich, are not liable to become fluffy: the worst cases are those with most organic matter, though admixture with coarse sand helps little if at all.

Bad effects from repeated bare fallowing also are clear in the "dust bowl" of the United States, and the similar prairie soils under alternate wheat and bare fallow in Canada. Here also the soils, having been under grass with low rainfall for centuries, were very rich. Analyses of the soils now "blowing" show nitrogen contents up to .5%. The trouble is ascribed by the experimental stations largely to the rotting of the fibrous roots of grass which used to bind the soil in clods, so that wind could not move them; but the chief trouble is deficient rainfall. While the result of the bare fallow has helped to convert fine prairie land into "dust bowls", we have no evidence on which we can convict direct sun effect of a share in the guilt, though we may suspect the effect of alternate wetting and drying to have been partly responsible for the production of the excessively friable condition.

The passages in Corbet's book dealing with Malaysian soils (to which Keiller refers) are—

> "Here exposure of soil to high temperature in a humid atmosphere does not result in conversion of humic material to a soluble form which may be lost in the drainage water, nor does a process of drying and washing out effect any appreciable transformation of soil organic matter into soluble form." "Almost the only possibility left is that increased insolation (exposure to sun) is responsible for a photo-chemical change, ... and experimental evidence has been adduced which shows that this explanation is almost certainly the correct one. . . . The precise nature of the chemical mechanism is obscure, but it has been shown by the writer in the laboratory that such nitrogen losses occur rapidly when soil is exposed to ultraviolet light in the presence of alumina." "The results obtained by Hardy show that free alumina is present in quantity in the lateritic soils of the equatorial tropics."

For experimental support for the above remarkable statements, Corbet refers us to "A.S. Corbet, Soil Science (in the press)".

The book was published in 1935, but no communication from Corbet has been published in "Soil Science" since 1934, and his earlier publications do not refer to this subject. Corbet himself admits that "the difficulty in accepting this as a complete explanation of the phenomenon is the apparent failure of ultra-violet light to penetrate any distance below the surface of the soil." In the absence of details of the experimental

work, we can regard Corbet's revolutionary statements as no more than interesting indications of possibilities under the particular conditions of Malaysia. How different these conditions are from those of temperate countries is stressed by Corbet himself, and our conditions in North-East India differ even more greatly. Corbet states that in Malaysia there are practically no seasonal differences; for example, the temperature at the surface of the soil (under jungle) does not change by more than 1°F.

Russell has stated that the Sudan results "were capable of being criticised."

The evidence for any harm from exposure of normal mineral soils to sunlight, in North-East India, therefore, is not considered to be strong enough to disturb generally accepted views, or to deter us from following a practice which is clearly good for other reasons.

2. Killing of weeds.

Where the land is not occupied by a plant which we want, our dry season gives an opportunity, which should not be lost, of using the drought to kill out weeds.

When we clear land preparatory to planting a preliminary green crop, we deliberately seize the opportunity of exposing the soil to the sun by leaving it in clods in November, so that most of the weeds may be dead by the following March, when we give a cleaning and levelling hoe before sowing our boga medeloa. When rain falls in the interval, an intermediate hoe is useful. Those gardens which clear in March and sow at once, grow more thatch than green crop.

For the same reason we like our land clean in the cold weather before planting tea in, say November. In this case, of course, the absence of weeds helps to retain moisture in the soil, but we also use a little dry grass round each young plant. You will see at Borbhetta about 16,000 one-year-old plants planted in October-November last, and though we had no rain from October 25th, till February 3rd, not a single plant has wilted.

3. Loss of fertility by land left without cover of plants when rain falls.

In North-East India we generally get useful rain starting in March though it may be delayed, particularly in the Terai. From May until about the end of September rainfall is heavy.

During this time the active factor is breakdown of the organic matter in moist soil at a high temperature, and leaching out of valuable products

of decomposition under heavy rainfall. This decomposition and leaching out go on whether the soil is exposed to sun or shaded, though exposure to the sun may raise soil temperature sufficiently to increase the rate of decomposition.

On generally accepted theories, it is not exposure to the sun which is the important factor in causing the increased rate of loss of fertility by soils without a cover of plants. The active factor is the absence of the roots of growing plants. In soil occupied by growing roots the rate of formation of nitrates, which means the rate of destruction of organic matter, is very greatly retarded compared to the rate in soil without plants. Further, such nitrates as are formed are very largely taken by the roots of the plants instead of being washed out. The plants also, even if not leguminous, provide carbohydrate, as fallen leaves or dead tissues, which allows fixation of nitrogen from the atmosphere to go on. The result is that soils closely occupied by plants gain in nitrogen and in organic matter. Soils without plants lose nitrogen and organic matter rapidly, under heavy rainfall.

We look upon the close occupation of the soil by plants for a year (or better two years) before replanting, as being fully as important as the direct gain of nitrogen from the atmosphere by the nodule-organisms associated with the legume: though it is better to have this factor also in our favour.

An increased rate of decomposition, however, would be an advantage rather than otherwise to the tea, if the products of decomposition were not leached out. The rain which does the leaching is the most important factor here.

When we have a crop of boga-medeloa, or arahar, to dispose of, we want this crude organic matter at least partially rotted down before planting tea. This is not only because "the crop gets in the way of the men digging holes," but because we want the products of decomposition in action on the newly planted tea.

Our problem then is to turn in the green crop in time to get it rotted before planting, but not to leave such an interval that we lose much by leaching before the tea can use it.

In this part of Assam we think we get better results by planting in October or November than at any other time, though this has not been proved by direct experiment. November also is rather a slack time: crop is falling off, and pruning has not begun. We like planting when growth is dormant, but don't like planting when the soil is as dry as it usually is soon after November. Failing November, I have a fancy for late

February or early March, before vigorous growth has started, and when we expect rain very soon. Late April, when growth is dormant after the first flush, also appears to be a favourable time.

We have no exact comparisons: but in our experience rains planting has not been satisfactory. The plant gets more of a check when lifted from the nursery in the growing season, and the necessary ramming is liable to puddle the wet soil around the clod.

The general practice, which has been very successful, is to slash down the green crop in September, and let it wither and rot on the surface till its volume is reduced. Our people are very short of firewood, and we encourage their children to take away the heavy stems: they are only a nuisance to us, and are valuable to them. There is trouble if a light stem or a leaf is removed. Leaves fall from the stems, very readily, soon after cutting.

About three weeks after cutting, a one-chop hoe gets the crop sufficiently mixed with soil. Just before staking, a light hoe is given with the special object of levelling, and the land is then ready for staking and planting. At this stage we encourage the removal of the stumps, to which heavy roots are attached.

In this part of Assam we can rely on good rain in September, and on at least one good shower in October, but we do not think we get enough to do much leaching within the period after the green crop is decomposed. After October we certainly do not get enough rain to do any leaching till the middle of March at earliest, and probably not till late April, though we always hope to get enough not to leave the soil very dry for very long.

It is to avoid loss by leaching of the land very sparsely occupied by young tea that we advise the sowing of a green crop between the rows in the early years after planting.

This year we were without cold-weather rain till February 3rd, when we got 0.37 inches, but we were not greatly worried about our tea, though we shall be if further rain holds off till April 8th, as it did last year.

In the Terai, a cold-weather and spring drought is not only much more likely, but it is almost a certainty.

It is presumably for that reason that planting in the Terai and Dooars is usually delayed until May, when rain is assured. Where May planting is projected, the turning in of the green crop could be delayed, but we still want it partly rotted before planting. I should hesitate for a long

time before attempting to dictate to a farmer with years of local knowledge, but I should think October would be good, since the soil is still moist enough to rot the green stuff. The green crop would make little growth in the following dry season. Whether leguminous plants go on fixing nitrogen from the atmosphere when they are not growing, I don't know, and I cannot find anyone who can tell me, but I should think it unlikely.

If rain does fall earlier than late April I would start planting as soon as it does fall, rather than leave clean land to be leached. If planting is not to start till June, the turning in of the green crop in May might be soon enough; but in that case we should lose the weed-killing powers of the drought.

Question 7. Medeloa in replanted tea.

This general question was discussed at the last conference. Here the only point is the relative effects of drying of the soil by the presence of the boga medeloa, and the reduction of the bad effect of drought by shade afforded both to the surface of the soil and to the young tea plants.

Here again we have no exact comparisons to quote. It is my opinion that, in severe dronght, the total soil occupied by the tea roots will be rather dryer where boga medeloa is used than where it is not used; but that the cover from direct sun on the young plants, and the protection from drying winds, renders desirable the retention of boga medeloa, in unbroken hedges running (as nearly as is convenient) north-west to south-east, with an inclination if any to north to south. It is from somewhat south of west that trouble comes, both from sun and from wind. That is, in this district: in the Dooars, the drying winds come from the East.

The hedges, however, should not be too thick in leaf, to transpire water. Personally I think the shade all that is required if the hedges are lopped severely up the sides, leaving these side branches which run in the direction of the hedge. If the hedges are carrying bushy tops I would lop these up the sides also rather than reduce height at this stage. This lopping I think desirable in October, after which the boga medeloa will make little growth till the following spring.

Mr. Scott stated that with regard to Mr. Cooper's remark that November planting might not suit the Dooars, planting at that time of year was often done and proved successful in many places.

Mr. McLennan asked what height was considered most suitable for pruning plants in the nursery.

Mr. Cooper said that it was possible to save a year if the cut was made low enough so as not to cut again. Thus the plants should be cut at the height which was intended for their first proper prune. As a very rough general rule he considered 6″ to be appropriate if the stems were as thick as the thumb. If they were thicker the cut should be lower down, if they were thinner the cut would be at 8″ or even higher.

Mr. Scott said that he cut at six inches with very good results.

Mr. Pearson asked if it was useful to retain a few leaves.

Mr. Cooper said that it was very useful, but very often was impossible. If the cut were made higher there were fewer deaths but it would be necessary to cut again later on.

Mr. Pearson observed that if he cut low, the white ants came in and killed out the plant. If he cut at 18″ or 2 feet the plants came away satisfactorily.

Mr. Cooper said that it was quite possible that a particular species of white ant would attack living tissues. We considered the white ant we have at Borbhetta to be extraordinarily useful in cleaning out dead material.

Mr. Tunstall emphasized that the cuts must be protected by painting with bitumen paint. This was very cheap and very effective.

Mr. Boyle asked if painting was necessary in the case of young plants.

Mr. Tunstall said that it was. He had found at Borbhetta old plants which had died, and the original cause of death was found to be infection of the first cut, made on the plant when it was 2 or 3 years old.

Mr. Cooper said that when we pruned at 6″ there was usually no trouble if the plants came away at the top of the stump. If they came away lower down then the stump died and did not heal and we had had cases of deaths ten years afterwards, due to the original cut. The centres of the bushes were found to be hollow and infected with various fungi. The best practice was probably to paint the wounds at cutting, and later on to go over the area again and clean off any dead snags, flush with a living shoot or branch, painting the new wounds as before.

The Chairman stated that such wound painting was a paying proposition and allowed one at least to start off with a sound bush.

Mr. Pearson referring to Mr. Cooper's remarks on the effect of sun on the soil, observed that the growth on south and west sides of teelas was

often poorer, than on the north and east. Was this not, at least partly, to be ascribed to the adverse effect of excessive sunshine.

Mr. Cooper said that this was not due to deterioration of the soil by the sun, but rather to deterioration of the bush from direct sunscorch, wind and drought.

Mr. Scott considered that Mr. Irving in his question on the use of boga medeloa, had possibly misconstrued Tocklai's statement that medeloa did not fix much nitrogen until it was mature.

Mr. Cooper said that obviously a large mature plant would have fixed much more nitrogen from the atmosphere than a smaller immature one.

Mr. Scott mentioned that Mr. Harrison at Dalgaon had stated that the amount of nitrogen returned to the soil before hoeing in an immature leguminous plant was very small, but if hoeing in was delayed until the leaves commenced to fall, the supply of nitrogen was greatly increased.

Mr. Cooper agreed with Mr. Harrison's statement. He mentioned that recent work had shown that nitrogenous materials were excreted by the root of certain leguminous plants, but these were unimportant as far as the tea bush was concerned. For all practical purposes we got nothing out of Boga medeloa until it was hoed in or leaves fell. It was possible that there was a time of maximum nitrogen fixation, but we did not know it.

Mr. Evenden asked whether, if the plant be mature when it flowers, would not that be the time of maximum fixation.

Dr. Wight observed that obviously one would get the most out of the plant when it eventually died though some nitrogen would undoubtedly be obtained at any time during the life history.

Mr. Cooper said that it was in his opinion best to leave Boga Medeloa as long as convenient.

Mr. Pearson asked when the seed should be sown.

Mr. Cooper answered that the practice in some districts was to sow immediately after uprooting. This was a mistake and resulted in more thatch than green crop. He preferred to uproot in November, leave the land in clods for the drought to kill out weeds till early March, when a light hoe would be given and the Boga Medeloa sown.

Mr. Scott observed that they rarely got real thatch grass on uprooted tea.

Mr. Cooper said that Mr. Scott's garden had been well cultivated before uprooting, but he was convinced that a better crop of medeloa could be obtained by this method of reducing all weed growth before sowing the green crop. At Borbhetta they would see excellent stands of Boga Medeloa containing practically no weeds, produced by this method on land which was previously under thatch.

Mr. Pearson referring to the question of lopping Boga Medeloa, agreed that lopping was necessary under some circumstances but he found it advantageous to leave it completely unlopped.

Mr. Scott agreed with Mr. Pearson. The practice was frequent in the Dooars.

Mr. Cullen stated that he found it satisfactory to cut across level to 3′ 6″.

Mr. Comrie said that loppings spread on the ground materially reduced loss of soil moisture.

Mr. Peason observed that with Boga Medeloa over 2 years old and lopped up the sides, there would be little shade below in any case.

The Chairman stated that he had seen in May on an estate in Ranchi, tea bushes killed right down to the collar simply by drying out. This drying was due not only to sun but also to a drying wind. An adjoining area had Boga Medeloa interplanted in it and the tea was in good condition. There was undoubtedly a loss of moisture from the soil due to the presence of the Boga Medeloa, but owing to the shade this loss was not great enough to affect the tea seriously. It was important to plant Boga Medeloa so as to provide the maximum shade, that is, since the sun travels overhead from East and West, the rows should be North and South.

The Chairman in asking Mr. Comrie to address the meeting on the subject of borers observed that recently a very large number of cases of damage from these insects had been reported, not only in tea bushes but in tea chests and in the bamboos of withering chungs.

Mr. Comrie then addressed the meeting as follows:—

Borers in young tea.—This form of damage is commonest on young thick stems about ½″ in diameter, *i.e.*, 2 year wood, and is caused by the Red Borer (*Zeuzera coffeae*). Owing to its scattered distribution it is not possible to take direct preventive measures against that pest. The most effective method of control found so far has been to make it a strict rule that the presence of any larva should be reported by the pluckers to the

Sirdar in charge, who carries a knife and cuts out attacked branches, and makes sure that the larva is destroyed. In this way, though the attacked branch is lost, it is made certain that the chance of further damage by that larva giving rise to a moth and laying eggs on other branches, is done away with.

Up to the present the only alternative hosts for larvae of such habits that we have found has been "Thoeilangoni" (*Eugenia balsamea*). "Phutuka," (*Melastoma*) which was thought to be a possible host, has not been found to be attacked.

Borers in Tea Chest Shooks.—Following on reports of damage to tea chest shooks by beetle larvae, a circular on the beetle responsible—*Stromatium barbatum*—has been drawn up and issued. These larvae are a common cause of damage to stored wood and also to wood-work in buildings. Only by constant watch can it be made certain that they do not gain a foothold and do extensive damage. The circular draws attention to the vigilance required when large stocks of shooks are carried, as is the case under present conditions. Even if no provision can be made for insect-proofing the store godown, the depredations of the beetles can be minimised by a constant watch being kept for signs or sounds of damage. It is bad enough to lose one board but when, as is often the case, one larva destroys 3 or 4 boards the matter becomes serious.

Borers in Tea Bushes.—Following on reports from the Halem area of extensive damage being done to older branches of tea bushes by a borer. Some of these borers were reared and the adult identified as *Monochamus Griseatus*—a long horned beetle. The same type of larva was recovered from wild Bauhinia stumps in the cleared area along the jungle edge—and since the incidence of borers lessened the further one went from the jungle, it would appear that the origin of infection was the jungle.

This year some similar larvae have been recovered during pruning at Tocklai, so that it is probable that there is a fairly regular amount of damage being done by this type of larva. The larva probably gains entry at a pruning cut where some slight decay exists and so gives a place which attracts the female beetle to lay there. The larva then bores down into the healthy stem. If one looks round after pruning there are many such holes to be seen bored into old tea branches. One method of deterring the females from laying on tea bushes would be to cover cuts which might give a suitable egg-laying site, with Indopaste or some similar paint. Dead branches on shade trees should also be attended to and removed because many of these show the emergence holes of wood boring beetles and probably act as a reservoir of infection from which the beetles come to attack the tea. In addition when pruning, any holes in branches which appear to contain larvae should be investigated and larvae

found should be destroyed by cutting them out or fishing them out with a piece of wire. It is easy to recognise a branch where such a larva has been overlooked, because the hole is seen to be freshly plugged by pieces of wood which are torn off the walls of the tunnel and rammed into the opening from inside by the larva.

Mr. Scott asked if there had been any other cases of Tiger Beetle boring into tea stems. The larva was very similar to that of the Red Borer, and a specimen which he had had identified by Mr. Andrews as Red Borer subsequently hatched out into a Tiger Beetle: He understood that the occurrence of Tiger Beetle in tea was rare.

The Chairman replied that this was the only case ever recorded of a Tiger Beetle larva boring in tea.

Mr. Comrie suggested that since the Tiger Beetle is a predatory insect, it had possibly chased out the original occupant of the hole and was not necessarily responsible for the damage.

Mr. Lagden said that he had two points to mention in connection with tea chests and linings. The Commissioner of Trade for Canada had informed him that experiments were in progress utilising maple and birch wood for tea chests. Samples were now on their way out here for testing. He was glad to be able to inform the Conference that all regular users of Finnish three-ply would be able to obtain their normal orders for 1940 and 1941. It would be possible to meet extra demands by supplies from Japan and China. There would be no difficulty with regard to aluminium foil linings. The position with regard to aluminium in England was very favourable. Should the present state of affairs deteriorate it will be possible to substitute lead linings (with paper between the tea and the lead lining). Enough lead to meet the whole of the requirements of both India and Ceylon can be produced in India.

THIRD SESSION, 17th February, 1940.

The Chairman in opening the third day's meeting called upon Mr. Comrie to address the meeting on the subject of Red Spider experiments.

Mr. Comrie, Tulsipara Spraying Experiment Plots.

In 1939, The Red Spider attack on the spraying plots at Tulsipara came late in the season and it was not until the middle of May that the attack was judged bad enough for spraying to be necessary. Seven treatments were tested and these were nine times repeated. The treatments were Murphy Lime-sulphur 1 in 30; Acme Dried Lime-sulphur 4 oz. in 12 galls. (*i.e.*, 1 in 80); Home-made Lime-sulphur, 1 in 15; Whizz A, 1 in 30; Dusted sulphur 10 lbs. per 200 bushes, *i.e.*, 120 lbs. per acre; Whizz, 1 in 30; and a set of control plots.

Brown Open-Hed Sprayers were used and the spray put on at about 170 galls. to the acre. The absence of one of the results associated with spraying experiment records in the past—namely a fall in crop immediately after spraying, is worthy of note. The absence of the fall was observed at the Tulsipara plots and also in two experiments carried out on young tea at Borbhetta.

The results of the experiment at Tulsipara were not significant. The highest yield was obtained from the plots sprayed with Murphy Lime-sulphur but the increase could not be regarded as significant. The attack was a fairly severe one and the bushes looked quite red. Though the spraying plots were the worst attacked by Red Spider of all the Tulsipara plots, no significant benefit was obtained by treating them. This result would tend to support the contention held by many people that a moderate Red Spider attack on healthy, vigorous, mature tea does not reduce crop so much as to make it economic for spraying to be undertaken.

A word of caution is necessary however; one must remember that the position is not the same as that involved in manuring experiments. With manures the tea is at a base yield and one aims at raising the yield. With spraying for Red Spider the yield is presumably depressed from what might have been—and (outside any stimulating or toxic effect of the spray materials) one must remember that the result one is measuring is the amount that the bushes are being brought back to the potential yield from which the attack has tended to reduce them. To test the drop in crop due to Red Spider and then compare that with the recovery owing to treatment is a matter requiring attention but this will require not only the laying out of many experiments but a great deal of luck in choosing

an area where a severe attack will take place at the time that such experiments are laid out.

Borbhetta Spraying Experiments—I and II.

At Borbhetta the Deamoolie plots of young tea were very severely attacked by Red Spider and two experiments were laid out on them.

Experiment I.—In the first experiment three dilutions of Murphy's Lime-sulphur—1 in 25, 1 in 50, 1 in 100; three dilutions of Home-made Lime-sulphur—1 in 12½, 1 in 25, 1 in 50; one dilution of Acme Dry Lime-sulphur—1 in 100; and control, were the treatments carried out.

The plots were sprayed on 17th April and the amount of spray applied worked out at about 80 gallons to the acre. A week or two after spraying the effects on the plots were very obvious, it was easy to distinguish the control plots by the depth in colour of the red on the bushes.

All the treatments gave a significant increase in yield over the control plots. The best yield was from the plots treated with Murphy Lime-sulphur 1 in 50. This was significantly better than Murphy Lime-sulphur 1 in 100 and Home-made Lime-sulphur 1 in 25 and 1 in 50. Though Home-made Lime-sulphur 1 in 25 had about the same polysulphide figure as Murphy 1 in 50 it was just significantly poorer in yield than the Murphy 1 in 25.

This experiment has one or two points of note:—

(1). The quantity of spray used.—This was in the neighbourhood of half the volume normally advised and used on young tea.

(2). The polysulphide content of the sprays was used in a comparison of the yields to determine whether there might be some correlation between the polysulphide content and the gain in crop. A significant linear regression was found and with this there was also a significant deviation from the regression. By leaving out the plots for Murphy Lime-sulphur 1 in 25 and Home-made Lime-sulphur 1 in 12½, which had a similar high polysulphide figure; and working out the correlation for the others, a linear regression with no significant deviation was obtained—in other words from the results of this experiment it would appear that up to a certain point, with an increased polysulphide content of the spray solution one may expect a direct increase in crop after spraying.

The results for the eight treatments were then examined to determine whether they might fit a curved regression better than a linear one. It was found that the figures were significant for a parabolic regression with no significant deviation. From this it would appear that up to a certain value of polysulphide under the conditions of this experiment one can expect an increase in crop, but that once a certain point is reached there is a danger that there will be a falling off in crop possibly due to a secondary toxic action of the spray. This result will require further experiments for confirmation but it is significant that in the past spraying has been associated with an immediate drop in crop, which is later counterbalanced, and made up, by the increase in crop. In addition there have been suggestions made that in spraying apples, etc., there is a certain amount of harm resulting from Lime-sulphur spraying even if no visible scorching is seen. It will be necessary to carry out a series of experiments to discover to what extent the effect does occur in normal practice. If this is shown to be the case it may then be possible to find what concentration of polysulphide is most profitable from the point of view of minimum effect in lowering crop while giving maximum effect in controlling Red Spider.

At the present time I think a dilution of Murphy Lime-sulphur of 1 in 50 is possibly the best to use. This may be slightly too dilute but should normally leave enough residue on the leaves to kill off young red spiders as they hatch from the eggs. Home-made Lime-sulphur is made by boiling Lime and Sulphur in the proportion of 20 lbs. *burned* lime, 38 to 40 lbs. sulphur in 20 gallons of water for about 30 minutes and not more than 45 minutes or until frothing stops, if this takes place before the 30 minutes is up. This should give a solution of 23·–25°Be and should be used diluted 1 in 20 to 1 in 25.

Acme Dry Lime-sulphur on these findings is effective at as low a dilution as 1 in 100 but I would not like to advise less at the present moment. This works out at slightly over 1½ oz. per gallon or 3 oz. in a 2 gallon sprayer which makes it a convenient rate for making up in the field. At 150 gallons per acre this would require about 14 lbs of powder.

In the second experiment the treatments were– Home-made Lime-sulphur, 1 in 25; Whizz 1/50; Liver of Sulphur; Tobacco Extract; Whizz 1/25; Ground Sulphur; Palestine Sulphur; Control.

The Liver of Sulphur and Tobacco extract gave no significant increase in crop when compared with the control plots. All the other treatments gave a significant difference between their yield and the control, Whizz 1/50 was almost on the significance level as poorer than the Lime-sulphur 1/25 which was the same solution as used in Experiment 1. From this I would suggest that 1 in 50 is the

lowest dilution that is advisable for Whizz and would prefer to use it 1 in 40 if not stronger, to ensure its giving a good kill. If it had been possible to include a third level of dilution it might have settled whether or not there is a regression in the effects yielded by different dilutions of Whizz.

The dusting with sulphur shows no significant difference in effect between the ordinary Ground Sulphur and Palestine Sulphur nor between these and Lime-sulphur spraying.

Note on Rate of Dusting.

At Tulsipara by timing the men on the dusting and spraying I found that whereas dusting is normally regarded as a much faster method of treating bushes, when it is being done carefully and thoroughly it is only slightly quicker than spraying, and if, as happened in this case, one got a heavy fall of rain at night, before the dust had time to act, the dusted plots showed no signs of killing the Red Spider on the following day while on the sprayed plots the kill was good.

Reports on Red Spider from Garden Managers.

Cachar Reports.—On nine gardens in Cachar the first signs of Red Spider recorded in 1939 are as follows:—

> February—1 garden, March—3 gardens, April—3 gardens, May—2 gardens, so that it would appear that the period March to April is the danger period. For the end of the attack the range is from May to September though the peak generally seems to be past by the end of June.

In only one case was more than half the garden attacked, in fact it is unusual to get more than 10% of a garden attacked.

With regard to management and its effect on Red spider there is remarkable unanimity in these nine reports that the management has no effect. In three cases the Managers hold that weak poor bushes are more liable to be attacked. In one case it was held that poor shade leads to attacks. Healthy bushes which are manured are held not to be so liable to suffer.

The opinions on the effect of skiffing only, versus cleaning out are not clearly put in some cases, but it seems to be felt that skiffing tends to increase the liability to attack though one manager takes the opposite view and holds that pruning weakens the bushes so that they are more liable to an attack than if just skiffed and not weakened by pruning.

In the garden worst attacked both pruned and unpruned teas were attacked so there is nothing from the records on which to base any suggestion with regard to avoiding an attack by pruning—this does not mean that the incidence may not be lessened.

At the present moment at Tocklai the biennially pruned plots are fairly severely attacked by Red spider whereas there are hardly any leaves present on the pruned plots which might carry Red spider. The presence of a large population of mites early in the year would lead one to expect a much more severe attack on the plots carrying the heavier infection at the start of the attack, but this can be very much offset, if conditions are favourable, by the high rate of reproduction of Red spider, which has a new generation every ten days.

There is no doubt shown by any of these reports with regard to the effectiveness of spraying in checking the activities of Red spider, nor is there disagreement as to the time of application of sprays. Some Managers hold that spraying should start whenever an attack is noticed —others advocate spraying in March and April. This amounts to the same thing in the end—because it is at this time that the attack starts. There is a suggestion that unpruned tea should be sprayed before pruned tea. This is also in agreement with the suggestion made above regarding the intensity of the original infection. The peak of attack on pruned tea would presumably be later than on unpruned tea which had a larger population present to start with.

The use of either Whizz or Lime-sulphur is advocated by 8 of the gardens, only one is in favour of Lime-sulphur alone. The dilutions vary from 1 in 30 to 1 in 80, but generally for Lime-sulphur (Murphy's) are about 1 in 60, and for Whizz tend to be more in the neighbourhood of either 1 in 40 or 1 in 80. This is interesting in the light of the Borbhetta results which tend to suggest that 1 in 40 may be the best rate for Whizz while the 1 in 80 is what I believe makers advise.

Spraying costs vary from Rs. 3/- to nearly Rs. 6/- per acre, the majority come in the range of Rs. 3/8/- to Rs. 4/8/-. This state of affairs can be expected when the rates of application suggested range from 100—200 gallons an acre, but the majority favour 120 gallons. This is also interesting to compare with the Tulsipara rate of 170 gallons, where the bushes are fairly large; and the Borbhetta figure of 80 gallons, on young tea.

Labour costs are on the average about Re. 1/3/- per acre but one garden goes up to Rs. 2/3/-.

Returns from other Districts.—Upper Assam—1; North Bank, 1938—4; North Bank, 1939—6. In these cases the gardens are more widely

distributed and comparisons are not so easy. If anything the attack appears to come earlier than in Cachar, only two records being as late as April. The attack also ends in most cases in May.

With regard to management more comments are made in these records—there is a feeling in certain cases that autumn manuring is better than spring manuring and that shade reduces the tendency to an attack. Good cultivation is also held to be helpful in warding off an attack.

Cleaning out and defoliation are regarded as good measures. In some cases they are held to ward off an attack.

Dusting and Home-made Lime-sulphur were used in some cases. There is no record of any treatment, aimed directly at the Red spider, not doing some good.

The general opinion for time of spraying seems to be that the best time is when an attack first appears.

The notes of dilution vary much with the different concentrates of Lime-sulphur used; which is what may be expected with Home-made solutions. Less mention is made of Whizz than in the Cachar records.

The costs vary from Re. 1/- to just over Rs. 2/- per acre, but I feel these figures are on the low side. It is not easy to estimate the cost of Home-made Lime-sulphur and some of the figures are lower for total cost than the mere cost of application on other gardens.

Mr. Macgregor mentioned the danger of defoliation in regard to young tea.

Mr. Cooper emphasised that as the young plant must have plenty of leaf in order to make the best growth, it would be unwise to defoliate young tea. Spraying must be resorted to and should be commenced before the attack became serious.

Mr. Pearson asked whether it was considered that attack by Red Spider was more severe on road-sides.

Mr. Cooper said that it was generally agreed that the attack started on road-side bushes and spread into the sections. It was carried by clothes of people walking into the tea and by cattle.

Mr. Burton said that he could not agree with the general idea conveyed in the replies to the questionnaires, that Red Spider attack on the

North Bank was generally over by the end of May. In his district, at any rate, it could extend well into June.

Mr. Winter referred to the possibilities of obtaining deciduous types of tea bushes which would not require defoliation in the cold weather to minimise Red Spider attack.

Mr. Burton said that he prepared Lime-sulphur of 30° Beaume strength on his garden at a cost of not more than 4 annas per gallon.

Mr. Cooper thought that attention should be called to the fact that methods for making Lime-sulphur were now quite different from those advised previously by the Department, as a result of work done in recent years on the method of preparation.

The Chairman said that the method now advised had already been described by Mr. Comrie. He also pointed out that the response to the Questionnaire had not been as good as was hoped and more reports were wanted.

Mr. Burton suggested that in future the Department should advise the delegates as to whom these questionnaires were being sent so that delegates might assist in getting more reports submitted.

Mr. Cullen said that there had been a considerable reduction in Red Spider attack in his district as a result of the removal of banjhi shoots by hand at the time of top-pruning on those sections which were not otherwise cleaned out.

Mr. Cooper said that manuring of mature tea by quick-acting manures had reduced Red spider attack but that cattle manure and compost, for some reason unknown, had increased Red spider.

Mr. Comrie mentioned that Red spider attacked nurseries even under heavy shade. It was pointed out, however, that Red spider might be very much worse on unshaded nurseries.

Mr. Evenden said that it was very noticeable during the 3-year pruning cycle in Darjeeling that in the pruned year (when there was practically no leaf left on the bush after pruning) Red spider attack was practically non-existent.

Mr. Pearson said that by leaving a fringe of tea along the road-side unpruned till March and then pruning it, subsequent Red spider attack was lessened on such sections.

The Chairman then called upon Mr. Tunstall to address the meeting on the subject of Branch Canker.

Mr. Tunstall.—In recent years a noticeable increase in the number of cankered tea branches has been observed. These cankers were commonly associated with infection by a fungus called *Macrophoma theicola*. Some however had no fungus at all in the dead tissues and it was at first thought that these must have been caused by *Corticium salmonicolor*. This fungus was actually observed in very few cases. Both these fungi do not usually initiate disease on tea plants in North-East India except under exceptionally humid conditions such as are found on hullah edges alongside heavy forest.

A series of laboratory experiments were commenced to find a suitable fungicide to apply to the diseased wood. We are still trying to find a fungicidal mixture which will penetrate the dead and decaying wood and prevent the fungi concerned from extending further into the living tissues. Such a mixture is specially desirable in the case of branch cankers which almost always occur on one side only of the affected branch. If the disease can be arrested many branches could be saved that otherwise require to be cut out.

We continued to recommend the cutting out of all dead and diseased tissues until we obtained evidence that such a procedure was not always necessary.

In the meantime observations were made in the field. The apparent effects of time and class of pruning, shade, manuring, etc., were noted. It was found that the death of the tissues occurred before any infection had taken place.

In all the cases I personally inspected it was obvious that the damage followed pruning and was associated with sun scorch. The time of pruning appeared to be the most important factor governing the incidence of the damage. Further investigations showed that most of the dead tissues remained uninfected by pathogenic fungi for at least a year after the damage had been done.

We have a number of experiments at Borbhetta in which pruning has been done at different times of the year. We have counted the number of bushes which show signs of sun damage and the results are recorded below.

The following tables show the figures obtained from our observations on the Doolia plots.

Affected bushes—Doolia side plots.

February, 1939.

Series.	Affected bushes per plot.				Total.	% of total.
1	0	1	0	0	1	0·4
2	0	0	0	0	0	0
3	60	66	62	57	245	95·3
4	53	49	37	37	176	69·8

February, 1940.

1	1	5	1	0	7	2·8
2	1	1	0	0	2	0·79
3	54	66	60	55	235	91·4
4	45	44	26	25	140	55·5

Significant Diff. = 13·3%

Plot set No. 1 was pruned in the ordinary way, in December annually.

Plot set No. 2 was unplucked in 1936 and was pruned in December, 1936, in the ordinary way. Since then it has been pruned annually in December.

Sets Nos. 1 and 2 were scarcely damaged at all by sun scorch.

Set No. 3 which had been rested for 3 years and then pruned to 20 inches on October 1, 1938, suffered very severely from sun scorch, some bushes so severely that they died. These bushes were in excellent condition when they were cut back and grew very strongly after the pruning in spite of the damage. Set No. 4 had been pruned every year on October 1st after being left unplucked from August 1st. The damage

on the bushes is much less than on No. 3 but still very severe. This, however, had not happened before this year although they had been pruned on October 1st for some years. It is clear that in the case of No. 4 the damage occurred in 1938 because the pruning was followed by ten days of very hot dry weather. There are two factors at work here. The sudden removal of very heavy or relatively heavy cover and the hot sunny weather following. The bushes just across a narrow path pruned to 12 inches 15 days earlier were much less affected but the pruning in that case was followed by wet dull weather. In that case also some of the bushes had been left unplucked for two months so that the removal of heavy cover was not a major factor.

In the case of Singlo plots which were pruned to heights ranging from 0"—28" in December, the amount of sun scorch was very little. Between these limits height of pruning has not had any significant effect on the amount of sun scorch.

The following figures have been obtained from the Matelli plots, pruned at 18 inches at different times and cultivated differently:—

Pruning times	CULTIVATION TREATMENTS.									
	Cheled monthly	One light hoe, and extra manure	Six light hoes	Two hand forks and sickled	Six light hoes	18" Deep hoe and six light hoes	Sickled only	Three light hoes and three hand forks	Totals	Average
1. July 15th	87	97	96	90	99	98	11	95	706	88·2
2. Sept. 5th	80	85	83	51	99	90	80	85	653	81·6
3. Oct. 27th	72	52	43	39	50	62	18	74	410	51·2
4. Dec. 18th	11	6	10	14	23	14	11	14	103	12·9
Totals	250	240	232	194*	271	264	153*	268	1872	—

N.B.—All plots had a 9" deep hoe in the cold weather except the one which had a double (18") deep hoe.

Significant differences

for cultivation treatments ... 73·4
„ time of pruning totals ... 104·0
„ time of pruning averages ... 13·0

The averages for the pruning treatments show that the October pruned plots were significantly less affected than those pruned earlier (July and September), but significantly more affected than those pruned late (in December).

The totals for the cultivation treatments show that both the under-cultivated plots (marked with an asterisk) bearing poor tea were significantly less affected, than the better cultivated ones with better tea.

The number of bushes damaged by sun scorch on the light leafed Mesai Manipuri plots which was pruned at 12" at different times is given in the table below:—

Treatment	Sept.	Nov.	Jan.	Total.
Kickers left, rested ...	104	56	37	197
No kickers left, rested ...	95	56	43	199
Kickers left, not rested ...	96	62	61	219
No kickers left, not rested ...	83	68	36	187
No kickers left, not rested, no manure	61	55	38	154
Totals ...	439	297	220	
Ordinary top pruning ...	December pruned			29

Sign. diff. for time of pruning totals = 13. Treatment totals no significant differences.

It will be seen from the above figures that the plots pruned in November are less severely affected than those pruned in September and the January pruned are less affected than the November pruned ones. But the number of affected bushes is much higher in case of pruning at 12" than top pruning in December. Resting for two months with or without kickers made no appreciable difference in the severity of the damage on these plots. The total for the unmanured plots (on which the growth was poorer) is much less than any of the others except the ordinary top pruned ones which were cut in December. The latter were hardly affected at all.

There is little doubt that most of the branch canker in North-East India is associated with sun scorch and is the result of the climatic conditions immediately following the time of pruning. Experiments are being undertaken to find out whether laying the prunings on the top of the bushes will provide sufficient shade to protect the exposed bark.

The tissues damaged by sun scorch rarely become infected by pathogenic fungi until more than a year after the damage has been done. In most cases wood rotting fungi invade the dead tissues and the rotting wood is often cleared out by white ants leaving a clean channel which ultimately heals over. In comparatively few instances are the dead tissues attacked by fungi which are capable of invading the adjoining ones. Even in these latter instances the progress of the disease is usually arrested without any specific treatment being applied. On this account I hesitate to recommend the cutting out of all damaged wood. Its removal would necessitate very severe pruning and the cure may be worse than the disease.

It has been frequently noted that the most vigorously growing tea often suffers more severely from this kind of damage. It also recovers very quickly without any special treatment. It is, however, possible that something can be done without undue expense to ensure satisfactory recovery. I hope to be able to say more about this when my observations are more complete.

The production of good callus is closely associated with the energy absorption by the leaves. It is, therefore, desirable to ensure that ample leaf area is left on the bushes and particularly on the damaged branches. Our observations suggest that from the point of view of callus formation better results follow the leaving of leaf in the course of the growing season than by leaving longer initial growth. I do not advocate complete resting in this connection as the subsequent exposure of the soft wood of the new branches may be followed by further sun scorch. The application of fungicidal sprays is unlikely to prevent or cure damage of this kind.

Messrs. Burton and McLennan agreed the terms 'light' and 'top pruning' should be differentiated. They understood that light pruning meant ordinary annual pruning leaving say ½" of new wood, while top-pruning conveyed the idea of skiffing.

Mr. Tunstall said that at Borbhetta it had been found that white ants helped to clean up the dead wood on tea bushes after medium or heavy pruning.

Mr. Burton referred to the low incidence of disease or sun scorch on the poorly cultivated plots and suggested that it might be due to the fact that those bushes had in the years previous to pruning, less top hamper, and had therefore been more exposed and hardened to the sun before cutting back.

Mr. Cooper said that all plots had been plucked alike irrespective of the cultivation and that he did not think there was much difference between them as far as exposure to sun was concerned.

Mr. Macgregor gave an instance where a certain section had been left to run up for five years, and before cutting down was about 17 ft. high. After the bushes had been cut back, the shade trees developed severe sun scorch on the lower part of the trunks, due no doubt to the sudden removal of the shade afforded by the high grown tea.

Dr. Wight referring to figures given by Mr. Tunstall for diseases resulting from pruning at different times of the year said that July pruning produced a different physiological type of growth compared to other times. It was concluded that the best time for pruning from the physiological standpoint was December. This agreed with our results on incidence of disease and with results on crop and quality.

REPLIES TO OTHER QUESTIONS

Cattle manure.—Whether the action of Cattle manure is accelerated by an application of sulphate of ammonia, thus preventing losses of plant food carried away in suspension in drainage water.

Mr. Cooper replied as follows:—

Sulphate of ammonia is more rapid in action than cattle manure, so that a mixture of sulphate of ammonia and cattle manure would act more rapidly than cattle manure alone; but the rapidity of action of the cattle manure is not likely to be increased by admixture with sulphate of ammonia. This opinion was founded on results at Borbhetta of admixture of sulphate of ammonia with resistant materials like prunings and cut jungle; but it has been confirmed by experiment on tea in Nyasaland that mixtures of cattle manure and sulphate of ammonia give about the same effect as the sum of the effects of the two used separately.

If the cattle manure is well incorporated with the soil, there need be no fear that it will be carried away in suspension in surface water unless the rate of soil erosion is great, when manure will be carried away with the soil.

One cannot avoid loss of nitrates in solution by percolation downwards; but on soil fully occupied by tea such losses are not great, and would be increased rather than decreased by increasing the dressing of nitrifiable matter.

Mr. Benton said that Mr. Cooper's conclusions were fully confirmed by laboratory experiments which seemed to indicate that a so-called slow-acting manure was in reality only a partially acting manure; in other

words part of its nitrogen was nitrified fairly rapidly but a certain proportion never appeared to become available at all.

Thullying.—Whether thullying can be considered a useful cultivation work.

Mr. Cooper.—We are not quite sure of the exact meaning of this word; but it is taken here to include all the operations which may be included in the act of forking around the collar of a bush.

If it means removal of soil to leave a deep cup around the collar, then we think it harmful: it damages roots, and the hole left becomes filled with water which only slowly seeps away.

We have no reason to believe that any good is effected by disturbance of the soil around the collar, and there is certainly no object in removing the soil around the collar, with the object of replacing it by soil from further away. There is no evidence in favour of the common belief that worm casts around the collar are detrimental.

Prunings, however, should be pulled back from the near neighbourhood of the collar: while if there are weeds they should be removed.

Where cheeling is practised the area should be clean after each operation: the hoe can be used to a point very close to the collar, and a very little pulling of weeds by hand finishes the job. In this case we do not give any special cold-weather forking.

Where we light hoe, the use of a hitting action close to the collar is discouraged, and although it is the duty of the hoeing man still to finish off by hand near the collar, there is commonly too much of such work to allow us to insist on it in the rush season, and we commonly have a special round of forking in the cold weather.

In Darjeeling, where sickling only is general in the rains, I expect that a round of cleaning round the bushes is generally necessary in the cold weather. In our opinion the sole object of this operation is the removal of weeds.

If the weeds are deep-rooted, like thatch grass, it will be necessary to use the fork deeply, but the aim should be to disturb the roots of tea as little as possible, and any soil removed in the process should be returned so that no hole is left.

Mr. Evenden asked whether cheeling (scraping) would not be just as good as forking round the bush.

Mr. Cooper replied that it would not, as thatch would not be killed out by merely cheeling the surface of the soil.

Mr. Burton said that in the Dooars, some years ago, they distinguished between the ordinary thullying and open thullying—the latter was done after bushes had been collar-pruned with the idea of inducing growth of new shoots from below the collar. He suggested that the word 'thullying' might have been derived from the word 'trowel'.

Mr. Scott referred to the effect of cheeling in smothering jungle and so killing it out; and described the method of cheeling employed on his garden.

Mr. Cooper said that thatch invaded tea from drainsides and it was then better suppressed by light hoeing than by cheeling.

Subsidiary Crops.—What is the attitude of Tocklai towards the so-called bye-products or ancilliary products of tea such as Thatch, Bamboos, Ikra, Fuel, etc., and is it considered right that the Department should be able to give technical advice on these points such as making of Thatch Baries, Fuel Baries, Bamboo Baries, eradication of Eupatorium or similar enveloping jungle where such interferes with the growth of thatch or the establishment of grazing ground, etc., etc.

If it is considered that Tocklai should be able to advise on these points, are there any plans to acquire technical knowledge for dissemination to those who wish for it.

The Chairman said that experiments had been started on treatment of Thatch Baries at Borbhetta. It should be possible to extend these experiments.

In regard to fuel, the Forest Department must have much information on this subject and also on Bamboos, etc., and he did not consider that experiments on these crops could be done at Tocklai.

A questionnaire on the whole subject should elucidate much valuable information which might be circulated amongst planters.

Dr. Wight pointed out that if experiments on this subject were to be attempted on a proper scale by Tocklai it would place serious restriction on the work already being done. He said that much information might be obtained from the Royal Agri-Horticultural Society of India, Calcutta.

Mr. Lagden pointed out that it was becoming more and more important that gardens should be self-sufficient in regard to supplies of fuel, bamboo, etc., and that work on these crops was very important.

Mr. McKay suggested that the assistance of a Forest Officer would be desirable, and in fact necessary if this work were to be undertaken.

Mr. Benton suggested that what Mr. Burton had in mind was the collection and dissemination of general information, and not much technical work would be required in order to obtain this.

Mr. Scott suggested that information should be collected by Advisory Officers on fuel, bamboos, etc.

The Chairman said that it would be part of the duty of Advisory Officers to collect all information they could on ancilliary crops.

Mr. Lagden referred to the Tung Research Scheme which had been put forward by Tocklai at the last Annual Conference and had been turned down in London. He suggested that this scheme might be put forward again.

The Chairman pointed out that by growing Tung, a source of fuel would be provided in addition to the main product of the tree.

Plants that kill Insects.—What information can the Department give on this subject?

(Newspaper cutting).

The Industrial Section of the Indian Museum, Calcutta, (Botanical Survey of India) has recently acquired and placed on show specimens of Derris root, commercially known as Tuba root, and flowers and plants of Pyrethrum.

The *Derris* root and Pyrethrum flowers are considered to be essential ingredients in insecticidal preparations used as dust or spray.

The *Derris* roots have been obtained from Assam, Bangalore and the Central Experimental Station at Serdang in the Federated Malay States, and the Pyrethrum plants and flowers from Kashmir and the Murree Hills of the Punjab. Some Pyrethrum flowers have also been received from

Harpenden in the United Kingdom, and Kenya. To make the exhibits attractive, pictures of the plant specimens drawn in their natural colours have been placed by their side.

More efficacious and less costly to produce, there has been in recent years a growing world demand for insecticides of vegetable origin, which are comparatively harmless to human beings to replace more dangerous arsenical and other chemical preparations.

Gardeners' Friend

It is said of "Tuba" or *Derris elliptica* that a decoction of the roots of this plant is the best remedy against the insect that infests nutmeg trees and causes them to turn yellow, and that it is a useful insecticide for gardening purposes too.

Insecticidal preparations from *Derris* have been tried with success in Assam against biting caterpillars which damage the cabbage crops. In Bengal, too, a preparation has been tried as spray against mango leaf hopper and found efficacious, but the cost is reported to be high.

Pyrethrum is another plant, the flowers of which are used as an ingredient in insecticidal preparations. Though a plant of the sea shore it grows also on the inland mountaneous localities and it has been found that sunny, pebbly calacareous soil on hill sides, dry and without irrigation and with fairly dry atmosphere, is suitable for the cultivation of the species which yield the insecticidal flowers. But the common Chrysanthemum, though a variety of this species, has not been reported yet to have any insecticidal properties.

Attempts are being made to cultivate "Tuba" in several parts of India; the plant grown in Mysore, in particular, has been found to give a good yield of rotenone, the active principle on which depends the value of these products as insecticides.

Analysis made at the Forest Research Institute, Dehra Dun, has shown that, while other species of *Derris* such as *Derris robusta* and *Derris scandens* (Noalata) or (Gonj) found in India contain little rotenone, the roots of the *Derris ferruginea* found in Assam give fairly good results.

A vast field, however, yet remains unexplored in Chittagong in Bengal and some parts of Assam, where several species of *Derris* are found to grow wild. It should be possible here to grow proper strains of

Derris elliptica the stock of which may be obtained from Malay, and thus obtain a larger supply of rotenone. The Malayan plants do not take long to yield the expected results. Thus Mysore imported *Derris elliptica* (Tuba) from the Federated Malaya States four years ago and grew the plant successfully, and two years' old plant yielded five to seven per cent rotenone.

Again, Pyrethrum has been successfully grown in Murree in the Punjab in experimental plots but its cultivation may easily be extended to other parts of India possessing suitable climate and soil, and proper strains may be obtained from Kenya.

The Federated Malaya States, the Dutch Indies, Phillipines, Kenya and Japan are doing an extensive trade in these plants. There has in recent years been an expansion of cultivation of *Derris* in the Federated Malaya States. In 1935 the area under cultivation was about 6,500 acres. The export of the root has steadily increased from 98 tons in 1931 to over 600 tons in 1936, valued at about Rs. 4,00,000.

In the Phillipine Islands, the *Derris elliptica* (Tuba) has been grown with such success that a substantial quantity of the roots is exported to the United States of America.

Tuba is also reported to grow wild in the forests of the Dutch Indies, and is, at present, being commercially cultivated in Java.

The particular species of Pyrethrum, from which the modern insect powder of commerce is obtained, is now largely cultivated in Japan and in the Kenya Highlands.

An enterprising farmer first put in only 25 seedlings in Japan in his own farm in 1896; in 1912 the area covered with this plant was 31 acres; but in 1937 the area had increased to over 60,000 acres yielding about 10,000 tons of dry flowers which brought a revenue of about Rs. 63 per acre.

In the Kenya Highlands the cultivation of this plant increased from less than 400 acres in 1933-34 to over 4,600 acres in 1936-37 producing over 1,000 tons of dry flowers of which more than 9/10ths were exported bringing in a handsome revenue.

In reply to this question the following information has been collected :—

The chief insecticidal plants in commerce are the two mentioned, *D. elliptica* and *Pyrethrum*. *Pyrethrum* has its home in Dalmatia but is now

grown commercially in Kenya, United States of America, and Japan. The ground-up flowerheads are used as a dust or extracted with light oils for use as a spray.

In Indian *Pyrethrum* is grown in Kashmir. The main factor controlling the pyrethrin content (*i.e.*, the toxic material on which the effect depends) is the water supply. For the best results a hot, dry summer seems the best—wet conditions reduce the quality of the flowers. The soil of the natural home of the plants is a broken-down limestone, but it was found in Britain that no significant gain in crop was obtained by the use of lime on a poor sandy soil of low fertility.

Last year we received some *Pyrethrum* 'seed' for trial but found that we had been sent what appears to be the commercial form of *Pyrethrum* which is the immature flower heads. A second lot of seeds has been obtained this year and we are now trying these out. I think if we can manage to rear the plants so that they bloom in the cold weather when conditions are drier there may be some hope of raising a crop of the flowers, with a good pyrethrin content, in the tea areas.

Apart from market possibilities there is always the use to which *Pyrethrum* can be put on the tea garden as an insecticide so that even if only a poor grade of flower can be raised it still may prove economic as an insecticide for consumption on the estate.

Derris elliptica.—This plant is a native of the Malaya States area and does not occur naturally in Assam. There are one or two estates experimenting with growing this plant and we have a few plants on the Station. Whether this is the same variety as is cultivated in Malaya we are not quite certain. The form here is a vigorous creeper. It was suggested by one visitor to the Station that the form grown in Malaya is more bushy than our specimens, but from the literature it appears that there are many forms of habit of growth among the strains of this plant in commercial cultivation.

There has been some confusion raised by the presence of a very similar plant, *D. ferruginea*, in Assam. This is a rambling climber and is more bushy than *D. Elliptica*. There has been no comparison of rotenone content made so far as I know. In addition there are several other local plants which are used as fish poisons which might prove worth while for selection for insecticidal properties.

Details of cultivation, etc., are given in the *Malayan Agricultural Journal* and these can be supplied to anyone particularly interested.

The roots can be used fresh, ground into a pulp and the extract sprayed on pests—or dried and stored. The toxic principle—rotenone—is more stable than pyrethrin and does not need such careful storing to retain its potency, though bad storing will tend to destroy its toxicity. The stored roots are also susceptible to beetle-damage and are better ground up and stored in tins for protection from such damage.

Mr. Burton referring to his experiments on the growing of *Derris elliptica* said that he had received unsatisfactory reports from the analysts in London.

The Chairman referred to experiments on crops which produce certain insect and fish poisons. This work was being done in Mysore and reports on its progress had been published by the Imperial Council of Agricultural Research. Some of these crops might prove of value in tea.

He said that *Derris* and *Pyrethrum* were under experiment at Tocklai.

The Chairman said that Memorandum No. 6 on Root Diseases of Tea which had just been published was a sufficient reply to two questions which had been submitted for information on Root diseases.

Manufacture.—Can the flaming of fermenting beds be overdone, thus adversely effecting the evenness and general action of fermentation, or is a daily flaming of beds considered advisable as against, say, flaming beds once or twice a week.

Mr. Benton.—We do not consider that bacterial control can be overdone. We have observed however that if a dirty factory is thoroughly cleaned and bacterial infection is eliminated, brighter and brisker teas are obtained with some loss in the depth of liquor colour. The only thing that can be said in favour of bacterial infection is that it may give a dark dirty coloured liquor, at the expense of briskness and brightness. The same effect could be obtained by adding bicarbonate of soda to the roll, and the probable result in either case would be a loss of market value.

I have discussed the case in question with Mr. Pearson and I consider that the trouble is not due to too much flaming, but to a high bacterial infection arising as a result of relying too much on the flaming lamp. Flaming is only effective on a dry surface comparatively free from tea residues. If thick deposits are present, the bacteria inside the deposits are protected from the heat of the flame by the damp outer layers, and flaming is not effective.

I have noticed an increasing tendency for Managers to concentrate on one phase of bacterial control, which is not in itself a complete treatment. Thus there is a tendency to regard metal leaf trollies, and metal faced roller caps as surfaces which keep clean automatically, or to regard the blowlamp as a universal sterilising agent. This is due to failure to appreciate the enormous rate of reproduction of bacteria. A single bacterium of the type found in factories can produce 12,000,000 bacteria in 12 hours. Metal trollies therefore require frequent washing if they are to be kept free from infection during manufacture. In cleaning machinery at the end of the day, water must be used to wash away juice and leaf residues. Water itself stimulates bacterial activity, and machines should therefore be dried after washing. Flaming is not effective on a wet surface but should be done before starting manufacture, when the machinery is dry, to destroy the bacteria which have developed on the damp surfaces overnight.

Bacterial control thus consists of four steps:—

(1) Thorough cleaning each night.

(2) Drying the machinery and floors after cleaning.

(3) Flaming the dry machines and floors next morning.

(4) Washing trollies (and in some cases, rollers) at hourly intervals during manufactures.

Floors and rollers should not be washed during manufacture unless the drainage is such that the washings can be removed from the working space; a clean water supply is also essential.

Mr. Benton also dealt with the following question:—

Quality of Rains Teas.—Why Tocklai considers that the Quality of Rains Teas can be equivalent to those of Second Flush when the moisture content of the rains leaf is higher.

We have not stated that the quality of Rains teas can be the equivalent of Second flush; this question was brought up at the 3rd Annual Conference, and my reply may be found on p. 84, which reads "I have never stated that second flush teas can be made in the Rains, although I think it very probable that Rains teas from good gardens a few years hence may resemble the second flush teas of to-day except for tip and possibly flavour."

If the term "Rains tea" is used to denote teas manufactured during the rains, then it is obvious that Rains teas alone can be made during the

Rains. If one uses the term to denote the soft dull type of tea previously associated with Rains conditions, then I hold that this type of tea need not be made at any time of the year; we have shown that brisk, bright teas can be made throughout the season, and that dull soft "Rains" teas are associated with bacterial infection, high temperatures and bad firing. I hold that dullness and softness is not normal at any season and is always curable.

Mr. Lagden suggested that Mr. Benton's note an "Extended Fermentation Test for Bacterial infection in Factories" should be sent out as a Circular and the Chairman agreed to do this.

White ant Exterminator.—Has any brand of white ant exterminator been tried out on the tea plant with any success? Such as Cowan's White Ant Exterminator.

Mr. Comrie replied as follows:—

I take it that this question is with regard to termite mounds being built in a tea bush and tending to smother it.

We tried out one of the proprietory powders on one or two termite mounds in the tea on this Station. One now appears to be dead, a year after treatment. The basis of these proprietory preparations is probably white arsenic though some appear to contain a certain amount of mercury and copper.

The advice given in Australia for dealing with a termite mound 3 ft. in diameter is to bore a hole into the centre and then blow in ½th oz. of white arsenic.

The aim in the introduction of arsenic is to cover the fungus gardens with a fine dust of the arsenic, this poisons the food supply and kills off many termites, and may even succeed in killing the queen if she were to receive poisoned food. Normally the colony usually dies out in 2 to 3 months. In addition to the direct poisoning action, certain fungi in contact with arsenical salts produce poisonous gases and thus the poison has a double mode of action. This gas production is one of the dangers involved in the use of arsenical preparations in treating termites in houses, but mounds in the open could be quite safely treated with hope of success.

With tea bushes it is often found that the only signs of activity of termites are the tunnels of earth on the bushes. To check these is scarcely economic and in addition it is doubtful whether the termites can be accused of doing serious damage. In the majority of cases they are cleaning out dead or decaying wood and so saving labour in cleaning up the

bushes. From the appearance of branches so cleaned up at Borbhetta, the cleaning out by termites appears to put a surface on the wood which resists further rots and decay.

From the cost aspect proprietory materials are far too expensive. The cost of white arsenic is 1-2 annas per oz. and $\frac{1}{8}$th oz. is held to be enough for one mound. This could be bulked with French chalk to ensure better distribution in the nest. The cost of such treatment is thus much less than by one of the proprietory powders which cost up to Rs. 10/8/- per lb.

When dealing with the usual termite tunnels on tea it is rarely that a mound can be found nearby and in these cases it is doubtful if it is possible to do any more than rub the tunnels off the bushes. After doing this a few times it is found in many cases that the termites give up their efforts.

Termites in Split Bamboos and Structural Wood-work.

There is another form of termite damage that it is worth while making reference to just now and that is the one connected with borer droppings in withering-lofts. The first impression I gathered was that the fine dust which falls when the bamboos are struck was the result of the activities of small Bostrichid beetles. These are on the wing at the present moment, but from what I have seen these are more commonly connected with fresh bamboos and do not show so much interest in old, weathered bamboos. Mr. Benton brought me a collection of droppings and it struck me that in shape they very much resembled those one finds in bungalows. At the same time in renewing wood-work in one of the bungalows it was found that these droppings, (which differed in colour, and this varies with the wood from which they are formed) were the result of the activities of a termite.

The American workers on termites, class termites doing this form of damage as Dry Wood Termites, because they have no need to have their tunnels connected to the soil for their moisture supply. So far as I have seen, they are the cause of most of the termite damage to furniture, window frames, etc., in Assam. By examining a series of attacked *kamis* (split bamboos) I found that the whole colony of dealated males and females, workers, soldiers, eggs and young can exist in the one *kami* and produce a steady rain of droppings which are pushed out of the holes in the surface of the wood. At the moment it is not possible to say how best one can protect *kamis* against attack by these termites because of the danger of any treatment used contaminating the tea. One method would be to treat the bamboos by heating them in Copper Sulphate solution but whether this salt is likely to creep into hessian in damp weather cannot be decided without experiment. The main trouble I should think would

be chemical action taking place between the salt and any metal work in contact with the treated bamboos.

If the bamboos could be soaked in water for about six weeks to get rid of all soluble carbohydrates, and when dried treated with creosote and left for long enough to lose any tendency to flavour the teas then I think they would remain free of attack for a long time. In experiments carried out to test the efficiency of various treatments it was found in the United States that creosoting was the most successful method of treating wood.

A great deal of the efficiency of a treatment depends on the degree of penetration of the protecting material into the wood. Good penetration is ensured by heating the wood in the creosote and allowing it to cool while submerged in the fluid, the heating drives out the air and the creosote is taken into the wood as it cools much more fully than if the wood is cold dipped or the creosote is brushed on.

The use of metal for the frames and woven wire for withering racks of course does away with all the problems involved in the use of bamboo for racks.

Mr. Benton made a suggestion that a light cloth should be stretched under bamboo chungs infested by termites, to protect leaf underneath from the droppings. He said that obviously the best solution was replacement of bamboos by wire; he added that until recently it was thought that wire-netting racks for withering avoided the bacterial infection which was likely to occur on hessian chungs, but that the latest work showed that wire racks could infect to a serious extent. Unfortunately no satisfactory method for removing this infection had yet been produced.

The Chairman then outlined the Programme of Work for 1940.

Most of the items mentioned in the Programme for 1939 have received attention but must be continued in the coming year.

The experiment dealing with thickness of spread during tea fermentation was not carried out, time and limitation of staff imposed a limit to the work that could be done. The experiments often required a greater amount of work than was foreseen and this necessitated limitation of the Programme in some other direction. It is hoped that progress will be possible in this coming year with those items that were unfortunately not dealt with to any extent during the past year.

Considerable limitation of manufacturing experiments arose by reason of the war, for as soon as this began it was no longer possible for the

London tea tasters to continue to give us their assistance. It was useless to carry on with manufacturing experiments that required tasters' reports. These had to be discontinued. This limitation will again arise during 1940 but we hope that the Calcutta tasters and other tasters in North-East India will come to our assistance even more than they so generously have done in the past, for unless we can obtain tasting reports the manufacturing experiments will have to be discontinued.

It is convenient to divide the Programme for 1940 into the same two main headings as in the previous year.

(1). Factors which Affect the Quality of Tea.

Medium pruning and quality of tea. In the 1939 Programme attention was called to the experiment on the cutting back of bushes that had become too high for plucking. These were pruned back at different levels and it is proposed to carry out manufacturing experiments during 1940 to ascertain the effect of the cutting back upon the quality. The aim of this experiment is to ascertain how soon after cutting back, bushes return to their normal quality. It is general planting experience that cutting back results in a loss of quality but for how long has not been accurately determined.

Withering.—The carrying out of experiments in regard to withering presents many difficulties but it is hoped to be able to carry out some preliminary work in regard to both the time and the degree of withering. A study of the chemical reactions that take place during withering is to be made; the final teas will also be tasted.

Rolling.—Work during the past year has shown that the system of rolling exerts control upon the micro-organic population present on the tea leaf. In some cases the population is greatly reduced. Further work in this direction seems to be very desirable and will be associated with an investigation into the increase in bacterial numbers during the fermentation process which commences with the rolling. The main reactions taking place during fermentation are now sufficiently well understood to allow practical application to be made and it is hoped to carry out work in this direction.

Fermentation: Humidity.—The air-conditioned temperature controlled cabinets that were installed last year for tea fermentation have proved satisfactory in regard to the temperature control but they have not given us all the conditions that we require in regard to humidity, and we have not been able to develop this investigation to the extent it was hoped.

With the installation of a mist chamber in the factory we hope to be able to extend investigations on the effects of humidity on fermentation.

Flavour, Aroma.—As might well be expected little progress in the practical application of investigations on flavour has been made, but it has been possible to formulate a hypothesis that fits the facts and is supported by what evidence is available. This has suggested critical experiments that it is hoped to carry out during this year.

Moulds.—The investigation on moulds is in progress and will be continued.

(2). Investigations for Improvement of the Tea Bush.

Starch.—The investigations of starch in the roots of the tea bushes is being continued.

Black rot, Thread blight. Field experiments are in progress for the control of Black rot and Thread blight.

Nursery disease.—Work is being continued upon the Nursery disease.

Branch Canker.—In 1930 an experiment was carried out on cutting back to various heights, bushes that had become too high for plucking. This is associated with another experiment in which is varied the time of the year at which cutting back is done. Some of the bushes have developed 'Branch Canker' which is common in many of the tea districts. The cause of this Canker has never been satisfactorily explained and the opportunity is being taken to examine the Cankers on the experimental area here. A field experiment on another series of plots is being laid out which it is hoped will give us further information about this trouble.

Vegetative Propagation.—Propagation of selected good quality bushes and of clonal rootstocks including such of the following experiments as prove practicable.

Selection of self-fertile tea plants: Classification of types into relatively self-fertile and relatively self-infertile groups (experiment will not be complete until cold weather 1941-42).

Selection of rootstock material—

(*a*) Raised from seed from selected bearers.

(*b*) Clonal material.

Pretreatment of cuttings with a view to inducing a higher percentage of rooting.

Tests of the manufacturing characteristics of material selected as clonal rootstocks (owing to the demands of other experiments it may not be possible to complete this work in 1940).

Tea seed bearers.—Pruning of tea seed bearers: The experiment designed by Dr. Woodford and commenced by the Assistant Botanist in 1938 will be continued. The object of this experiment is to give some ideas of the physiological response of the tree on which recommendations for or against pruning treatment may be based—the treatments are not in themselves to be regarded as practical methods. The experiment has been designed to test statistically the differences in the number of flowers and fruits set on shoots receiving the different pruning methods.

The experiment has been designed so that it will be possible to measure the significance of the variance due not only to treatments but also to jat and the position and aspect of the branches on the tree.

Records of the number of flowers and fruits set on the shoots up to the last lateral grown in the previous season will be made from time to time.

Two experiments are in progress to ascertain the effect of manures upon the seed crop; one in its first year at Borbhetta and the other started last year on a garden in Cachar.

Clonal seed.—Nurseries raised from seed from free pollinated clones—*i.e.*, clones not isolated and presumably pollinated from surrounding tea—will be compared with the seed from the usual mixture of seed bearers. In this latter case there is the element of variability in both the male and female side: in the case of the free pollinated clone, female variability is eliminated.

Shade.—At Borbhetta a field experiment is in progress to find out what may be the interaction between shade, nitrogenous manuring, and the jat of tea. In this case shade is limited to one particular tree *Albizzia stipulata*.

Another experiment has now been started with the object of ascertaining the effect of using different kinds of shade, and seven different trees will be used. The effect of potash and phosphatic manures will also be studied in this connection.

In addition there are 14 experiments on estates throughout the tea districts dealing with this important investigation.

Field Experiments.—We have now approximately 50 experiments that are being carried out on estates. It is hoped that in spite of the war conditions it will be possible to maintain these experiments.

Arrangements have been made for 29 new experiments to be started this year, of which the preliminary yields of most were obtained during the past year.

All the experiments which are in progress both at Tocklai and Tulsipara are being continued.

General.

Mr. Cooper. Mr. Cooper will be retiring in April of this year. I can only say how much I regret that he feels it his duty to do so.

Home-leave.—No officer will be on home leave this year.

Lecture Courses.—It was thought inadvisable to hold Lecture Courses whilst national affairs were in such an unsettled condition with the recent outbreak of war but with the increasing organisation for national services and the clarification of the position regarding liability to service I think it should be possible to hold the Lecture Courses again at the end of 1940.

Annual Conference.—The Fifth Annual Conference will be held in February, 1941.

Touring.—The Touring Programme for this year is a comprehensive one and I hope it will be possible to carry it out completely. The names of the districts to be visited are given below:—

Assam	Surma Valley	Dooars	Darjeeling	Terai
Dibrugarh	Luskerpore	Oodlabari		
Panitola	Balisera	Dam Dim		
Naharkatiya	North Sylhet	Chalsa	Subdistricts	All
Moran	Chargola-Longai	Nagrakata	by	
N. Lakhimpur	Hailakandi	Binnaguri		gardens.
Nazira	Chutla Bheel	Dalgaon	arrangement	
Jorhat	North Cachar	Toorsa-Jainti		
Bishnauth	Lakhipur	Jainti-Sankos		
Tezpur				
Borsola				

Advisory Branch.—The Advisory Branch has now become an established section of the Experimental Station and it is hoped will attain normal working order during this year, although I would again call your attention to it being on a restricted basis. This has been recognised by the Indian Tea Association in that they considered the appointment of another Officer who would be allocated to the North Bank of Assam. Unfortunately with the outbreak of war, considerations for the appointment of this officer had to be postponed until a more suitable time.

Mr. Macgregor who joined the Department in September, 1939, as Senior Advisory Officer, will be resident at Tocklai. The other three Advisory Officers will, it is hoped, shortly be taking up their residence in their respective districts. The first duties of these Officers will be to make themselves acquainted with their districts and it is hoped that the various managers will give them every help. Whilst it is realised that these Officers with their scanty experience in tea will not be in a position to give very much first-hand advice, this should not deter planters from consulting them, for it must be remembered that these officers are in close and constant touch with Tocklai and it is through these Officers that the normal liason between the planters and Tocklai will be maintained. These Officers will assist individual managers with the various field experiments that are being carried out in the districts.

Mr. Pearson suggested that if possible the Conference might be held later in February as the present dates clashed with A. F. Camps.

The Chairman said that this matter would be borne in mind when arranging the dates of next year's Conference.

The Chairman asked Dr. Wight to address the meeting on the matter of publishing an Encyclopaedia of Tea. He mentioned that the delegates had had the opportunity during the Conference of seeing typed specimen copies of some of the subjects which it was proposed to deal with in the Encyclopaedia.

Dr. Wight outlined the reasons for publishing such information as we had collected on various subjects connected with the scientific and practical aspects of tea growing. He explained that the subject matter had been extracted from various Memoranda and more detailed publications, and said that he thought that an encyclopaedia produced on these lines should be of great value not only to the Department but also to those concerned with the practical side of tea planting. He suggested that there were three points to be decided by the Conference, namely :—

(*i*) Whether to publish the Encyclopaedia or not.

(*ii*) Whether or not it should be published in loose-leaf form.

(*iii*) What means should be adopted by the Department to maintain continuity in view of the fact that such a publication could never be considered as complete and would constantly require addition and emendations.

Mr. Maclennan proposed that the Encyclopaedia should certainly be published in its present form as seen by the delegates.

Mr. Burton supported the proposal.

It was further agreed that the publication should be issued in loose leaf form so that it could be added to at various times.

Mr. Macgregor suggested that it was quite unsuitable for publication in its present form. He thought that an attempt had been made to make it too comprehensive, at the cost of plainly worded information of the type likely to be sought. The general opinion of the meeting was that it would prove very popular, and Mr. Burton suggested that Mr. Macgregor might be rather underestimating the intelligence of the managers in suggesting that this publication might prove frightening to them.

Regarding the means to be adopted by the Department for ensuring continuity, the Chairman said that this must be left to him.

Mr. Lagden thought that it should be issued complete with binder and indexed in a simple manner.

Mr. Lagden suggested that a precis of the Annual Report for 1939 should be issued as soon as possible.

He pointed out that as far as the Lecture Courses for 1940 were concerned, much depended on the war conditions. It might prove possible to hold only one or two weeks Courses instead of the usual three weeks.

He asked whether in regard to new planting at Borbhetta, the Department had already planned experiments to be conducted on the new areas.

Mr. Cooper said that about 11 acres would be planted this cold weather. 6 acres was already designed for experiments on shade trees: the remainder would be ready for that experiment thought most useful at the time.

Mr. Lagden asked the delegates to remember that it was part of their duty to think of concrete suggestions in order to increase the success of future Conference. He considered that in the case of districts sending

2 or more delegates to the Conference, one of them should give way to a new man every two years or so.

He appreciated the fact that scientists generally had a dislike of committing themselves on paper but suggested that the Department had a great deal of valuable information which ought to be made available to the planters: for example a useful publication would be a simple schedule of the "do"s and "don't"s of tea. This would be particularly useful, he thought, for factory men and young planters.

In the course of a few remarks on the question of national service he pointed out that scientific officers would in general be of greater use in technical spheres than serving in regiments.

He assured the Advisory Officers that when they went to their respective districts they would find that the tea industry would give them every help possible to carrying out their work.

In referring to Mr. Cooper's impending retirement Mr. Lagden proposed that this delegation record their very high appreciation of all the work that Mr. Cooper had done for the tea industry. He moved the resolution "We have all appreciated his great help, we have all recognised his great knowledge, and we all sincerely wish him the best of health and happiness at Home."

Mr. McLennan said "Mr. Lagden's resolution requires no seconder, but on behalf of the Assam Branch, and I am sure I speak on behalf of all planters, when I say that we should like to associate ourselves with what Mr. Lagden has said. Mr. Cooper's retirement will be a very great loss not only to the Tea Industry but also to his many friends."